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The British Journal of Surgery

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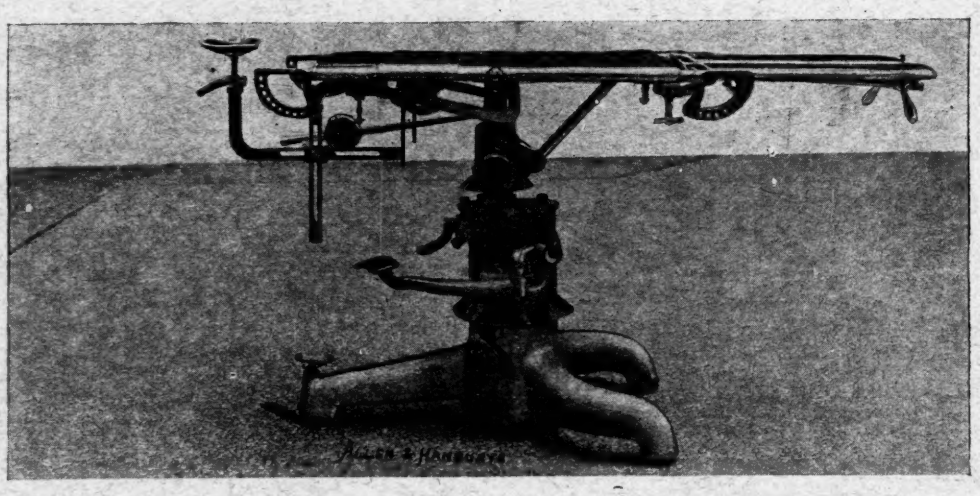

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THE
BRITISH JOURNAL OF SURGERY

INTRODUCTORY.

A REVIEW of the work of surgeons during the past momentous four years of military service, and its relation to the future of the practice of surgery, is a gigantic undertaking little suited to a short introduction to the sixth volume of the BRITISH JOURNAL OF SURGERY, while so little are we in a position to grasp or even conceive the actual conditions under which we shall live and work when the blessings of peace are again vouchsafed to us, that a forecast can provide but speculative interest. Yet it may not be unprofitable at this juncture to take stock of a few of the conditions which exist at the moment, and to ponder upon the influence these may possibly exert on the practice of surgery and the life and position of the surgeon in the future.

The great outstanding features of military surgery lie in the possibilities which are provided by the casualties of battle for the rapid accumulation of facts and experience in a special field, and in the wide distribution of this work amongst a large number of medical men to whom under ordinary conditions the active practice of surgery might have been restricted in many instances to the narrowest limits, or even avoided with studious precaution.

These conditions have permitted a combination of men representing every branch of medicine to join in collaborative research of a character and extent which ordinary circumstances could never have allowed, and effected a general assimilation of thought and aim difficult to conceive under the comparatively water-tight-compartment arrangements which exist in times of peace. Yet, side by side with the general breadth of outlook which has been thereby in great measure attained, a tendency to an undesirable degree of specialism has sprung into existence. It is to a consideration of these features that the following cursory remarks will be confined, and of the question as to how far they promise to exert an enduring influence on individuals who have been suddenly translated from a strenuous or an easy-going life, and whose energies under the conditions of the previous fifty years might have been confined to a narrower sphere and expended perhaps on an inglorious routine broken only by an occasional holiday or attendance at a medical meeting.

A glance may first be taken at the material resources in medical personnel at the disposal of the War Department. The officers available may be conveniently grouped as follows: (1) *Newly-qualified men, and qualified men who found themselves unattached and free at the outbreak of war;* (2) *Settled general practitioners;* (3) *Consulting physicians and surgeons, specialists in the various departments of medicine;* and (4) *Workers in pure science.*

1. The first group—consisting of volunteers, fresh young minds abounding in energy and the desire to win their spurs on their simultaneous entry into the arena of active life and into the field of military service—has afforded a most useful asset. As a class, a little over-anxious perhaps, to wield the knife, or to join the forefront of battle—where many, alas, have laid down their lives or become permanently handicapped for

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the future. The unattached, often a globe-trotter, has brought knowledge of men and of life under the conditions of distant climes which has often rendered him useful under circumstances totally unfamiliar to the newly-fledged surgeon. The value of such an assemblage of plastic material to the regular service can hardly be overestimated. On the other hand, no single body of men has derived more benefit from its association with the war. Habits of discipline, opportunity for estimation of their own powers and capability, medical and surgical experience, and even material improvement in personal health and strength, have been acquired as a result of military service.

2. The general practitioner, as representing the actual body of the profession, has proved himself the strength and corner-stone of the medical service. Habituated to onerous and regular work, an experienced student of human nature, and accustomed to deal with emergencies of every kind, he has thrown himself into the great work of the service with an energy and carelessness of self which is beyond all praise. Many of them, moreover, brought not only medical skill and experience, but also administrative capacity, developed as a result of prescient patriotic service with the Territorial Force, a virtue which has been but too inadequately recognized and repaid. Yet this group of men also has gained some advantages which civil practice could not afford, such as a change of life, and the not infrequent possibility of devoting themselves to particular lines of work specially germane to their tastes and capacities: small recompense, perhaps, for a virtually abandoned practice, and for the constantly recurring thoughts of the trials and troubles inflicted on those left at home or in the temporary shelter which the Territorial officer's means have allowed him to provide for those nearest and dearest to him.

3. The consultant physician and surgeon, a class to which a defined position had already been allotted in foreign armies, entered the Service under such indefinite conditions as can never again occur. It seems incredible that no actual scheme of duties should have been assigned to the consultant in the reorganization of the Medical Service which followed the South African War: prospective duties of which so broad an outline has been sketched by the late Director-General of the Army Medical Service in the pages of this journal *:—

> They set the scope and standard of practical work and scientific investigation. The Administration relies on them for the fixing of surgical policy. The responsibilities of these officers are great; their efficiency is proportional to *their own* appreciation of their powers. They determine whether the means at the disposal of the hospital surgeons are adequate or not. They supervise the operations and approve the operators, so that upon them depends whether or not all that is best in British surgery is available for the soldier. . . . Nothing less than the almost complete transference of responsibility for the surgery of the war to special officers can satisfy the conditions.

None the less, it remained for the consultant officer at the commencement of the war to feel his way into the position, although cordially and heartily helped by those in authority, both at the War Office and in the field.

Never before has the specialist played such a prominent part in the field of war, neither could the train of inconsistencies which has attended his utilization have been foreseen. On the one hand, those to whom work of a general character happened to be assigned were often anxious to develop special departments galore; while, on the other hand, some of those restricted to the performance of the work of their own choice craved for a wider sphere of action. The latter is perhaps readily intelligible, for the joy of emancipation, when the opportunity of engaging in more general work offers, to the man whose time may be divided between operating for adenoid vegetations and chipping away fragments of the mastoid bone, or to the ophthalmologist whose main duties may consist in removing damaged eyeballs or determining errors of refraction, can be easily conceived. Even the gynæcologist, with his ever increasing operative opportunities in civil life, has been not unwilling to devote his operative skill and energies to another sex

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**Brit. Jour. Surg.*, 1916, iv, No. 13, pp. 3, 4

and a wider territory on the human frame. Let it be said, however, that no recruits to the field of general surgery have more amply justified their ambitions, or more readily fallen in with the exigencies of the situation, than the specialists.

4. Lastly, we have the man of pure science—the physiologist, the pathologist, or the philosopher. The position of these workers has been unique; never before have they met the practising doctor in such broad and intimate association, with corresponding opportunities of disseminating their knowledge, of utilizing its practical application, and of inducing habits of thought and reflection in the mass of the profession.

Let us now turn to a cursory consideration of the work that has had to be undertaken. The subject of administration has been dealt with in these pages in the paper already referred to. It suffices, therefore, to make the bald statement that without good administration good surgery is an impossibility. At the same time the two are interdependent, since the methods and devices of the surgeon may determine great administrative issues, such as questions of transport of the wounded, or the possibility of rapid return of men to their units in the line. The surgeon may fairly claim to have done much to solve many knotty problems in this direction, and to have well fulfilled his share of duties of enormous importance to the efficiency of the fighting machine.

It is notorious that medical staff work, and the administration of medical units, have been carried out with conspicuous success during the entire course of the campaign. For this result the country is indebted to the officers of the Royal Army Medical Corps, who have abundantly justified the efficient prospective preparation and training instituted and maintained during the years subsequent to the reorganization which followed the South African War. In the matter of medical units, however, it has been a striking object lesson to observe the efficiency with which many have been organized and administered by civilian practitioners, the majority composed of men who had previously undergone training in the Territorial Royal Army Medical Corps. Many of these latter, indeed, have administered their units in as faultless a manner as the best regular officer: exhibiting capacity for organization, the faculty of ready improvisation, and power to meet unexpected difficulties, which has excited the greatest admiration and respect from their civilian brethren. Beyond these previously trained officers, the practical experience of war has developed the faculty of military hospital administration in not a few purely civilian practitioners to whom the subject had been hitherto absolutely unfamiliar, and many of these also have proved themselves second to none.

The aptitude for administrative duties, and indeed the earnest desire to undertake them, has been a somewhat unexpected revelation in the ranks of the civil profession. The phenomenon may be put down in part to the sense of relief engendered in many men by a change of daily routine; in part, perhaps, to the satisfaction of assuming duties the regulations for which have been set down with such exactitude that it is possible to carry them out without error or undue worry; or, again, to the fact that to a certain number of men a position which entails the personal control of others always makes an appeal. Moreover, this craving for administrative power has not been confined to any particular group of the men engaged, but is met with amongst all classes.

Before proceeding to a brief review of the nature and results of the surgical work actually performed, it may be worth while to inquire how far either the civil or the military surgeon was prepared to undertake successfully the treatment of gunshot injuries of the nature they have been called upon to deal with.

The sequence of events in this matter has assumed an oft-repeated type. The most modern observations in military surgery on which reliance was placed related almost solely to wounds inflicted by bullets of small calibre of a particular kind. The nature of these wounds was well understood, as also their comparatively innocuous character, provided the soft parts of the body alone were affected. This knowledge was founded on direct observations made on wounded men; and the variations likely to accrue from the

altered ballistic qualities of the pointed bullet had been foreshadowed both by experimental investigation and the limited experience gained from the Russo-Japanese and Balkan Wars. The expectation of having to deal with wounds of limited extent, prone to heal spontaneously without any active surgical aid, consequently dominated the views of the military surgeon at the commencement of the campaign.

It cannot be said that experience regarding the primary nature and subsequent course taken by wounds caused by bullets of small calibre has in any way deviated from that observed in previous wars, except in the one important particular that more frequent irregular impact of the pointed bullet has occasioned the occurrence of a larger proportion of wounds in which the degree and extent of contusion of tissue is increased.

Our preliminary deficiencies lay in the fact that we allowed it to be necessary to rediscover for ourselves what our grandfathers and great-grandfathers could have taught us: the terrible nature of injuries produced by fragments of shells and bombs—characterized at the present day by a still greater degree of destruction of tissue as a result of the introduction of high explosives. We were well aware that wounds caused by bullets of small calibre healed easily, but we also knew "that shell wounds, with the exception of tracks caused by clean leaden shrapnel balls, always suppurated," in spite of the fact that patients suffering from either shell or bullet wounds might be exposed to identical conditions and surroundings.* Our shortcoming lay in the fact that we appreciated neither the number of shell wounds we should have to deal with, nor their gravity and extent.

The second problem that awaited us was the suitable application of the principles of wound treatment. Better instructed than our forefathers as to the actual causes of the accidents and complications which may interfere with the physiological process of reparation, in civil surgery we had developed a system, on the groundwork of the principles laid down by Pasteur and Lister, by which wound infection is avoided and reliance placed solely on the natural processes of the body.

It may be fairly claimed that in civil practice the aseptic system has ensured better average results than had ever before been attained, and upon this system, with certain minor antiseptic additions, the military surgeon proposed to rely. The gross nature of the infections met with, however, led in the first instance to failure in the methods employed, although time has shown that the failure was really the result of their imperfect application. Primary failure was followed by an eager grasping at chemical antiseptic media, employed with the object of retarding, controlling, or arresting the progress of the process of infection. A fresh evolution of successive steps commenced, ending in a definite separation of the methods of dealing with infected and non-infected wounds respectively, and in renewed reliance on the normal process of spontaneous repair, together with a conviction that chemical media deal only with organisms developing on the surface of the wound. Further, that infection of the tissues can be best arrested by mechanical removal of the infected area, adding as precautionary measures excision of devitalized tissue capable of forming a suitable nidus for bacterial growth, and such arrangement of the wound as will prevent retention of body fluids likely to form a favourable culture medium.

Thus, as the outcome of patient effort, a rational standpoint has been attained, and certain definite conclusions arrived at: (1) That effective primary disinfection of a gunshot wound should be mechanical in nature, and that if this procedure be radical, such a wound (provided that treatment be undertaken sufficiently early and amidst satisfactory surroundings) may be closed as safely as a wound entailed by a surgical operation. (2) That in view of the many difficulties which may accompany military surgery, primary closure of the wound is often better replaced by the so-called delayed method, i.e., closure at the end of three or four days. (3) That attainment of a sterile surface, and subsequent closure of primarily infected wounds, may be promoted and hastened by the employment

* Makins, *Surgical Experiences in South Africa*, first edition, p. 486.

of suitable antiseptic media; also, that the antiseptic method is particularly valuable as a means of ensuring the possibility of early secondary closure of granulating wounds —the type of closure applicable to gunshot injuries in almost any circumstances, and hence the most valuable of all.

Passing from the subject of general principles, it may be asked how far the surgery of the future is likely to be influenced by the enormous experience gained in the treatment of gunshot injuries.

A deeper and more practical interest has been taken in such matters as the nature and treatment of shock and hæmorrhage, and attempts to deal with these conditions by intravenous administration of drugs and by the transfusion of blood have been undertaken on a scale far beyond anything that has been practicable before. These methods, although still in the balance, have received strenuous support from many quarters, and it is reasonable to assume that progress has been made.

The treatment of compound fractures has occupied a very prominent position. The observation of a large accumulation of imperfect results obtained in the surgery of war has only confirmed the unsatisfactory experience as to interference with function which had been already acquired when opportunity was taken to examine the ultimate results of fractures in general amongst any large body of men, such as the police force. Here, as in so many other directions, the urgent need for national economy—in the most important direction for the future of the empire, economy in man-power—has deeply and favourably influenced surgical practice, and realization of the importance, not only of returning men to the line, but also of conserving useful if not physically perfect citizens, has been more and more impressed upon surgeon and administrator alike. There can be no doubt that methods of transport, of discriminating primary treatment of the wound, of immobilization, and of rational after-treatment, have received an impetus which will exert a permanent influence on the surgery of the future.

Wounds of the great articulations constituted a perplexing problem; but while the power of the synovial membrane to deal spontaneously with infection has been more generally recognized, and has resulted in more rational views as to primary closure of the joint cavity; and, in the case of suppurating joints, in dealing when possible with the cavity of the articulation—that is to say, a well-bounded space—before the extra-articular structures are involved in the infection, the general lines of treatment have only been brought into consonance with those which have guided the civil surgeon for many years. Again, experience gained of the results of primary and secondary excisions of the joints has been but a repetition of that of the civil surgeon in the treatment of infected joints met with in connection with injuries, acute infections of the bones, or in tuberculous disease. A disposition to resort freely to excision has been followed by a reaction in favour of expectant methods, imposed by observation of the ultimate results of the more radical procedure.

Extended observation of methods of treating wounds of the large blood-vessels and their after-consequences, has led to increasing confidence in a more active attitude in either the early or later stages, and to a more general development of operative technique in the attempt to effect repair rather than to proceed at once to occlusion of a main trunk. Ideal results, however, can hardly be said to be common, since ultimate thrombosis of sutured vessels has occurred in a considerable proportion of instances, and it still remains doubtful how far improvement in technique will obviate this disappointing termination, when dealing with the contused injuries resulting from gunfire. One great principle of pre-war surgery has been practically reversed, as evidence has been furnished that simultaneous ligature of the satellite vein accompanying a large artery is to be preferred to that of the artery alone. Again, the adaptation by Tuffier of Carrel's method of temporarily maintaining the circulation in a divided artery by the introduction of a junction tube between the separated ends, in order to gain time for a gradual increase of the collateral circulation, will form a permanent addition to the resources of the surgeon.

Active intervention in injuries of the central organs of the nervous system has been enriched by the introduction of many technical details, but little change in general principles has been evolved. The main subject of argument and contention has consisted in determining the most suitable moment for intervention by the surgeon. The chief gain in this field has been furnished by the labours of the neurologist, which have resulted in an increase of knowledge which must prove of the utmost value in the future both in the investigation of disease and in regulating the intervention of the surgeon. Knowledge of symptomatology, and of the indications for immediate or late treatment of injuries to the peripheral and sympathetic nerves, is steadily increasing, and in this field a permanent advance seems fully assured.

Perhaps the most far-reaching development is that met with in the treatment of injuries involving the thoracic cavity. It is of interest to recall the grounds upon which this has been evolved. First, upon observation of the favourable course taken in a certain proportion of the gross injuries in which the cavity of the thorax had been laid open, and the conviction gained that the more frequent fatal issues depended upon consequent infection of the cavity rather than upon the primary gravity of the traumatism. Secondly, upon confirmation of the views, so ably put forth by Macewen, that artificial arrangements for the maintenance of respiration are unnecessary in dealing with the opened thoracic cavity. Although the rules guiding intervention in cases of injury to the chest may still require some regularization, the experience gained of the value of operative measures in properly selected cases, and the safety with which they may be carried out, prove that a large field has been opened up to the civil surgeon in the future.

One of the most striking triumphs attained, the establishment of an active, in place of an expectant, attitude in the presence of injuries to the hollow abdominal viscera, will hardly affect the future of abdominal surgery beyond the confines of military service; it is a triumph of the military surgeon over prejudice and the former imperfect application of rules that had long guided the civilian practitioner; but for the wounded soldier the change of view which has been attained must be regarded as an inestimable boon.

The general conclusion which is to be drawn from the results obtained is mainly to the effect that military and civilian practice have been drawn into closer conformity. The false but widely enough entertained view that there is something special in gunshot wounds, and that they require a surgery of their own—beyond the facts that tissue destruction is great, that a great proportion are grossly dirty, and that the surroundings and equipment may be in some cases totally unsuitable for operative intervention—has been proved to be incorrect.

This brief review of the probable general effects of the surgery of the present campaign on military and civil practice, leads up to another important issue which has been brought to the forefront by the administration of the Medical Service of the War. This question cannot be better introduced than by a quotation from the Introduction to the fourth volume of this Journal, on "Surgical Organization in War" * :—

> If we cast our regards around us, we find a tendency more and more to classify the wounded into groups, demanding experts in special branches of knowledge for each class. This is inevitable, and suggestive of changes in the future. The system has not been in the first place designed, nor established of set purpose. It has evolved, and the advantages are so apparent that it has been encouraged . . . Its educative value is enormous, and it offers unique opportunities for research. Unlike many other tendencies, there are no administrative objections to it, and it can be suffered to grow and flourish without the production of a narrow specialism.

It may be at once agreed "that there are no administrative objections to the system," and we may go further and assert that administrative considerations are those which have carried the main weight in its introduction, in much the same way that financial

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* *Loc. cit.* p. 7.

considerations bear a far from insignificant part in furthering the growing tendency of late years to the increase of specialism in civil practice.

To a limited extent specialism is rational and inevitable. This has been fully recognized in specialities which demand particularly fine technical detail, such as the surgery of the eye, the ear, or the throat. Methods of investigation and meticulous operative technique, demanding prolonged training, and capable of utilizing an enormous field for practical exercise, have justified and indeed rendered necessary the establishment of these departments in medicine, and even of hospitals devoted solely to their particular objects. The segregation of the patients in special hospitals, however, is purely a question of administration and convenience, and not the outcome of actual medical or surgical requirements; moreover, such hospitals are supplemented by special departments in the general hospitals which the general surgeon and specialist alike would see relinquished with regret. Specialism in these directions must be regarded not only as an advantage, but also as a necessity; but if the specialist is to retain his highest degree of efficiency and utility, his relation with his colleagues in general medicine and surgery cannot be too intimate, and it is undeniable that the broader the general culture the specialist possesses the greater will be his efficiency even in his chosen department.

The specialism born of military administration stands on a far different basis, and in the interests of the surgery of injuries it will be nothing less than deplorable if, for the future, diseases and injuries are to be classified into groups demanding experts in special branches of knowledge for each class. We may first note the natural result, dependent upon the common tendency of human nature. The surgeon who does not expect to be called upon to treat any particular disease or injury loses interest in the subject, and becomes either less capable, or incompetent, to deal with it; hence his breadth of view and general efficiency tend to narrow in every direction in which a new so-called speciality is set up. The specialist himself is liable to become still more restricted in outlook, unless he be a man of unusual energy and determination. Limitation to a narrow field, while it may provide the opportunity for the development of technical facility, on the other hand obstructs the entrance of the many sidelights which may illuminate the special province if the surgeon be engaged in general work at the same time.

The history of surgery shows clearly enough that if the science is to continue to progress and develop on broad and comprehensive lines, the advance must be the result of the efforts of the general surgeon, and not of men whose energies are directed and views confined solely to one small area of the human frame. To whom for instance are we indebted for the evolution of the true principles of wound treatment? To Hunter and to Lister, men whose sympathies extended over the widest area. Note the catholicity of Astley Cooper, although his name is now principally remembered by his special work on fractures and dislocations. The surgery of the stomach owes its genesis to Billroth; that of injuries of the intestines to A. Cooper and J. Croft; that of the kidney to Morris and Lucas; that of the central nervous system to Macewen and Horsley; ovariotomy—the precursor of the later triumphs of abdominal surgery—to Spencer Wells; the plastic surgery of the palate to W. Fergusson: all general surgeons in the proper sense of the term. A mere glance at these names raises another aspect of the question; a general surgeon who shows aptitude in dealing with any special class of case becomes in a sense a specialist in spite of himself; either in hospital work or in private practice he will have little choice but to deal with the class of disease which his fellow practitioners see fit to send to him. This form of specialism should suffice, and may indeed represent the ideal from the point of view of the patient, although it may by no means always meet with the same sympathy and content on the part of the surgeon concerned.

The tendency to develop specialism on military lines is of a far more stringent character. We find a specialist for the treatment of fractured jaws; another for fractures of the thigh; and, strange inconsistency, we meet with a third department, that of orthopædics—for which a special course of a few months in some instances suffices to qualify—claiming almost the whole field of the surgery of injuries. From an adminis-

trative point of view in dealing with the huge accumulation of the casualties of war, the convenience of such a system may be allowed, as also that it has been attended with a considerable measure of success, and benefit to the soldier. On the other hand, when the peculiar conditions of war are ended, the segregation of patients scattered over the entire United Kingdom to such a degree is impracticable; therefore, while the experience gained by the system may be of value, its continuance is undesirable as well from the administrative as other points of view. Come what may, the great mass of the population must be cared for by the local surgeon and general practitioner; and the proper policy of the future is to enlarge the opportunities open to these men of obtaining experience, and to provide them with ample means and facilities for carrying out any form of treatment, and not to seek to limit their range of thought and action.

In centres of medical education, the segregation of various classes of case in separate wards may be useful for purposes of instruction, but this should not require also the appointment of a specialist in the narrow sense of the term. Every general surgeon has special aptitudes and predilections, as has been abundantly shown in the past, and it is in this direction that special instruction should be sought for and provided. Individual surgeons may vary in their ability to perform faultlessly any particular operation; but this in no way affects the more important questions of scientific knowledge and insight, and of their capability of making advances in the investigation or elucidation of problems raised by the disease or injury for which the operation may be needed. Is it possible to imagine a school which is to produce the ideal physician or surgeon presided over by a collection of specialists? For the future of surgical science no less than for the dignity of the profession, let the professor remain a surgeon, and not descend to the position of a stomatologist, a urologist, or a proctologist.

To pass from the vexed question of specialism, we may next briefly consider what is likely to be the effect of military life and experience on the individual surgeon, and on the surgical calling as a whole. Certain influences must be wholly to the good, others may be regarded as uncertain in their ultimate effect.

The first and one of the most important is the intimate connection which has been established between workers in pure science and in the practice of surgery. The man of science has been living under the same roof and under the same conditions as the surgeon, and both socially and professionally an intimacy of relation has obtained such as has never previously existed between them. Never before have the physiologist and the pathologist come into such close contact either with the practitioner or the patient—with the result, it may be ventured to say, of humanizing the man of science, and at the same time of allowing the practitioner to drink more freely and intelligently of the stream of knowledge which the laboratory worker is in a position to pour out. By an unexpected course of events, consequent on the special nature of the warfare, the hospital ward has become the chief department in the laboratory of the man of science, and the surgeon his main collaborator. The chief source of difficulty in ensuring the most useful lines of work experienced in laboratories unattached to institutions for treatment of the sick has thus been eliminated. The scientist has been able to observe the direct results of the adoption of his recommendations, while the surgeon has not had blindly and submissively to put in practice methods as to the evolution of which he has been more or less ignorant. These circumstances afford an illustration of a method of broadening surgical views in singular contrast to the trammels imposed by recourse to specialization in the treatment of each form of disease. This close association of pure science and surgery is one of the features of recent military work the persistence of which in times of peace is to be most earnestly desired and looked forward to, as likely to open up the path of progress in the future.

Other instances of the establishment of a closer relationship are not wanting, as, for instance, that of the consulting physician and surgeon. It cannot be denied that in many cases the long-existing relationship between these two great branches of the profession has

become of late years somewhat less intimate, principally perhaps as a result of a feeling on the part of the surgeon that the physician was not always in sympathy with some of the more active methods of modern surgical treatment of disease. The entrance of the consulting physician into the domain of military work has done much to correct this feeling, and in fact in some fields the physician has proved even more active in his views than his surgical colleague.

The consultant has never enjoyed a better opportunity of appreciating the breadth of knowledge of medicine and of human nature possessed by the general practitioner, or of seeing illustrated the mutual understanding which should exist between doctor and patient. Under no circumstances can the bond of sympathy be greater than that which exists between the wounded soldier and the surgeon on active service, since they are brothers indeed, striving side by side for the same object and under the same conditions of life. The countryman has perhaps seen a truer picture of the consultant, separated from the normal surroundings of either hospital or social life, and has found him a man of simple tastes enough, and not unwilling to put his hand to duties which a dresser might shirk if possible. Even the almost comic rearrangement of the professional standing of the older and younger men, much irritation as it sometimes occasions, may not have been in all ways a disadvantage; seniors have revived their recollections of their own junior life, and the teacher his own ways when a pupil, while wearied minds have been spurred and stimulated by contact with the young and fresh.

In fact, the general intermingling on common ground and under identical conditions of every branch and grade of the profession can hardly have failed to establish a better mutual understanding and a closing up of the ranks which should have a persisting influence on the body politic, and lead to an increase of its importance and dignity in the community.

The influence of this long period of military service upon the individual surgeon, on his aspirations, his mode of life, and his future destiny, is harder to appreciate or forecast. The settled practitioner, removed either voluntarily or compulsorily from his normal surroundings, has been living through a "sort of interval between the parts" on the stage of life, his whole aims and ambitions interrupted, and placed under conditions in which the common responsibilities of life are either diminished to a negligible degree or have vanished completely. The period of suspension has been indefinite, the duties often far different from those for the fulfilment of which his scheme of life had been planned. To some has come the happy chance of merely shuffling off uncongenial shackles of existence; some have become engaged in work far more congenial to them than that they left; others are constrained to perform duties for which they have no liking and feel ill-adapted; while practically all enjoy that strange sense of ease accompanying diminished personal responsibility, and inseparable from the unfamiliar despotism implied by the magic word discipline, under the influence of which their lives are now being passed. The kaleidoscopic re-arrangement of the whole profession which must result when normal conditions return can hardly be foreseen, but a few words may be devoted to the possible influences which may specially affect the practitioner of surgery.

On the professed surgeon these will be slight, except in the favourable effect likely to follow a break in routine, the freshening of thought and ambition, and an increase in general breadth of view. The more important problem will arise in the case of those who up to the advent of their period of military service either entertained no surgical ambitions, or foresaw no opportunity of realizing them; or, again, in those at whose feet opportunities have fallen at the very threshold of their career which might have dazzled even the experienced surgeon. We may safely assume that with the advent of peace a large proportion of the men of either of these classes will yearn to continue the surgical practice in which they have been engaged during the war.

Certain conditions calculated to make this the more easy will probably be found, such as the wide development of more or less well-equipped voluntary hospital units unwilling to suddenly cease their activities; the fact that it will be long before the surgical flotsam and jetsam of war has been finally disposed of; and, again, the circumstance that

the surgeon will return with a reputation of having been actively engaged in a field of surgery offering great opportunities and a very wide scope of activity.

It may be asked how far experience gained in the field will have fitted its possessors to engage in similar work under the conditions obtaining in normal civil life. To some of these the interest will be in surgery as a science; to some it may mean no more than the capability and opportunity to undertake operative work. However pure may be the aspirations of the surgeon, it cannot be gainsaid that the operative side of surgery instinctively appeals to most of its students and practitioners, and to some it constitutes the whole end and aim. The power of relieving mind and body; the possibility of eradicating disease or repairing injury; the relations which a successful operation may establish between surgeon and patient; the knowledge of the pathology of disease which may be obtained by the opportunity of investigation during life; and lastly, the material gain which may accrue to the surgeon himself: all combine to render operative surgery a fascinating department of medicine—but also to emphasize the necessity of maintaining a proper perspective in the use of the knife. While no doubt can exist that the foundations of many successful surgical careers have been laid, and that strictly surgical work will be more widely distributed than in the past, yet the path to surgical practice in time of peace and under normal conditions may not be so smooth and easy as it has appeared when distantly contemplated during the quiet intervals which the military surgeon enjoys between the times of stress.

Military service indeed, while of the highest value, yet fails to supply much of the training and experience required for success in the practice of surgery. In the first place, the field is limited in many directions. The patients for the most part are young and healthy men; their injuries are of a class but rarely met with in ordinary life, and their treatment is undertaken under very special circumstances. The military surgeon works under conditions very unlike those of peace. Putting aside the bond of mutual sympathy which life in the field does so much to encourage, the intangible and far-reaching influence of military discipline enters into every issue. A soldier is not his own, his every act is conditional on the will of his superior officer, and consent on the part of the wounded man to any course recommended by the surgeon is accepted unhesitatingly in a like spirit. Such self-abnegation might be thought impossible; but a strange feature of human nature surges to the front and makes it far easier to understand than might be imagined, even bearing in mind that the soldier appears to think an operation the only form of treatment that can put him right. His willingness to submit himself depends upon the same relief experienced in escaping from the exercise of personal responsibility which permits him to be happy and contented in the field although torn from his home and normal surroundings, and which passes with him from active duty to the wards of the hospital. How far this characteristic may persist amongst old comrades in the army it is difficult to say, but even if the patient remains equally docile, this will not eliminate the influence of anxious friends upon the surgeon's mind, and questions of treatment will not be so easy of determination as at a casualty clearing station or a hospital on the lines of communication. It must be appreciated, too, that the work in military hospitals in time of war is done in a surgical atmosphere; the surgeon is free from all distractions of professional worry or social engagements; it is rare that serious work must be undertaken except in close association with others similarly employed; and there is little chance of the sight of the future village cripple troubling the walks abroad of a Charles Bovary.

The last remark brings into prominence one of the most unsatisfactory features of military surgery from the educational point of view—the impracticability of following cases to their ultimate issue, and in a great majority of cases the impossibility of observing more than a limited stage of the treatment of any particular form of injury. Even in face of the prolonged period that war has persisted, this disappointing feature has not been eliminated, although great pains have been taken to attempt to obtain continuous histories by a system of correspondence, and efforts have been made to allow surgeons from the front line to make visits to the hospitals on the line of com-

munication. Continuous observation of the course of individual cases has, however, been impracticable, and this has been a serious disappointment for the surgeons concerned. The consulting surgeon and the medical meeting have played important parts in this direction, but even here the arrangement by which the consulting surgeons work on parallel instead of radiating lines has done much to modify the advantages that might have been derived from their presence. In their respective areas the consultants have done much in regularizing and diffusing knowledge, for it is remarkable that the same odd disinclination of men belonging to neighbouring units to visit each other is found in military hospitals in the field as in a town at home. Our colonial and American colleagues have also done much to break in upon this spirit of aloofness, as well as to stimulate our energies in many directions.

Near or distant as may be the happy moment to which we all look forward, now is the time for meditation, and for the formation of plans of life; and if this desultory table-talk serves to quicken reflection, it will not have been set down in vain. Fortunate are those who during this period of storm and stress have been able to decide upon the life they hope to lead; and to none is a more useful prospect likely to be opened up than to members of our calling.

GEORGE H. MAKINS.

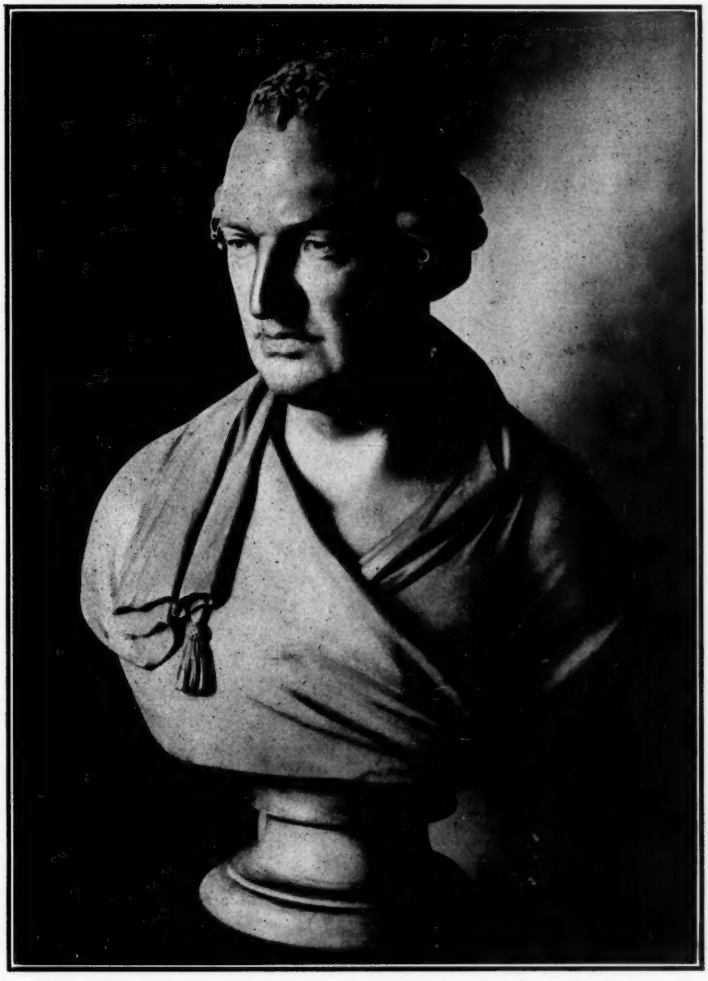
HENRY CLINE.

1750—1827.

THE Cline bequest, after the lapse of three generations, has at last come into the possession of the Royal College of Surgeons of England, in the form of French Rentes. It is a direct reminder of the French Revolution, and of the views held by a distinguished contemporary English surgeon in regard to that great upheaval.

Henry Cline was born in London on March 25, 1750, and was educated at Merchant Taylors' School, in Suffolk Lane, which he entered in 1759, the headmaster being John Criche, who was soon afterwards succeeded by James Townley, the author of *High Life below Stairs*. In August, 1767, Cline was apprenticed to Mr. Thomas Smith, one of the surgeons to St. Thomas's Hospital, for the statutable period of seven years. This apprenticeship not only entitled him to his master's teaching, but it allowed him to attend as a pupil at the hospital, and gave him a claim to a surgical post at St. Thomas' hospital in the event of a vacancy. The position of surgeon depended nominally upon the vote of the whole body of governors; in reality the only competitors were the hospital pupils who had served their apprenticeship to the surgeons. Cline made such good use of his opportunities that he frequently lectured upon anatomy to his fellow students before he was out of his indentures, taking the place of Joseph Else, the appointed Lecturer in the School. On June 2, 1774, he was admitted a member of the Surgeons' Company—the successor of the United Company of Barbers and Surgeons, the immediate predecessor of the College of Surgeons of England. In this year he says: "I had the happiness of hearing the first course of lectures which John Hunter delivered. I had been at that time for some years in the profession, and was tolerably well acquainted with the opinions held by surgeons most distinguished for their talents, then residing in the metropolis; but having heard Mr. Hunter's lectures on the subject of disease, I found them so far superior to everything I had conceived or heard before, that there seemed no comparison between the great mind of the man who delivered them and all the individuals, whether ancient or modern, who had gone before him." This is a remarkable testimony to the influence of Hunter's teaching upon the more receptive minds of a younger generation, trained in the older school of surgery, but ready to advance upon the new road shown them by our great master.

In 1775 Cline married Miss Webb, and took a house in Devonshire Street, E.C., moving a few years later to Jeffries' Square, St. Mary Axe. Joseph Else died in 1781; Cline was appointed Lecturer on Anatomy and Surgery at the school of St. Thomas's Hospital in his place, and, as was then the custom, bought his predecessor's museum and anatomical preparations of the executors. In December, 1784, Thos. Smith, the surgeon to whom he had been apprenticed, died, and Cline succeeded him. He was thus enabled to receive pupils, and amongst the first to be sent to him was Astley Paston Cooper, then a lively young scapegrace who soon strained the patience of his uncle, William Cooper, surgeon to Guy's Hospital, to whom he was first apprenticed. Cline exercised a control which was all for the good of Cooper, whom he soon converted into a hardworking anatomist, thus laying the foundation of his future greatness as a surgeon. Cline himself worked steadily at St. Thomas's Hospital as Lecturer on Anatomy and Surgery, gaining a reputation both as a good teacher and a successful operator. Practice, however, came slowly, and he did not consider himself firmly established until he had arrived at the age of forty-five. From this time onwards his income increased until, at the age of 60, Sir Astley Cooper estimated that he was making upwards of £10,000 a year, and adds that it might easily have been much more if he had been less fond of politics and farming. On



HENRY CLINE, SENR.

From a bust in the Great Hall of St. Thomas's Hospital.

November 11, 1793, he examined Edward Gibbon, the historian, and found that the swelling he had long considered a hernia was in reality a hydrocele. Cline tapped it, and drew off 160 ounces of fluid, and a fortnight later he tapped it a second time, drawing off 120 ounces.

In 1796 he moved to Lincoln's Inn Fields, then the fashionable neighbourhood for successful surgeons, and on July 7, 1796, he was elected a member of the Court of Assistants of the Surgeons' Company, in place of William Walker, who had died whilst one of the two wardens of the corporation. The election was a remarkable one, because the meeting of the court at which it was made put an end to the legal existence of the Corporation of Surgeons. This originated from the following circumstances : By the Act of Incorporation, 18 Geo. II, the Court of Assistants of the Company was to consist of a master or chief governor, and two governors or wardens, with other members, of whom it was enacted that the master and one warden, together with one or two ordinary members, should form a Court for the dispatch of business. On this occasion, William Walker, one of the governors, died in May, 1796; the other governor, John Wyatt, was lying blind and paralytic in Warwickshire, and was so ill that it was impossible to move him. When the Court met, therefore, the master—William Cooper—and some of the other assistants were present, but not *one* of the governors or wardens as ordained by the Act. The meeting was not a court legally, but those present proceeded with the business, and elected Cline into the Court. The legality of the action was disputed, counsel's opinion was taken, and it was found that the Corporation had been destroyed. A Bill was brought into Parliament to legalize the action of the Court, but was thrown out in Committee. It was then determined to apply for the establishment of a new body, and in 1800 a charter was granted by King George III to establish a College of Surgeons. The Surgeons' Hall in the Old Bailey was sold, and the new College was established on its present site in Lincoln's Inn Fields.

In 1808 Cline bought some land at Bound's Green, and becoming greatly interested in agriculture, lost much time and money in its pursuit. In politics Cline was a devoted adherent of Horne Tooke, whom he attended professionally when he was a prisoner in the Tower, and afterwards in his last illness. For many years he gave an anniversary dinner to Tooke's friends and supporters at his own house in commemoration of Tooke's acquittal. He was also a friend of John Thelwall—the political agitator—and showed him much kindness. He was greatly in favour of the French Revolution, and by his influence with leading men in Paris secured Astley Cooper's safety during a three months' residence there in 1792.

In 1811 Cline resigned his office of Surgeon to St. Thomas's Hospital, and was succeeded in it by his son Henry Cline, junior. In 1815 he became Master of the College of Surgeons, and in 1823 he was re-elected to the same position, which was now called by the more high-sounding name of President. He died on Jan. 2, 1827.

Cline's reputation has been somewhat overshadowed by the fame of his pupil and colleague, Sir Astley Cooper ; yet by his contemporaries he was held in very high esteem, both as a man and a surgeon. As an operator he was neat, cool, and determined. He seldom praised, and never censured ; the kindness of his disposition induced him to put the most favourable construction on the actions of others, and rendered his manners peculiarly mild and conciliating. He was never eccentric or sarcastic, and to him vanity, arrogance, or self-sufficiency were strangers. He was constitutionally reserved and solemn. Sir Astley Cooper says of him that he wanted industry and professional zeal, liking other things better than the study or practice of his profession. In politics, a democrat ; in religion, a deist. A good husband, son, and father. As a friend sincere ; as an enemy most inveterate. He was mild in his manners, gentle in his conduct, humane in his disposition, but, withal, brave as a lion. His temper was scarcely ever ruffled. He appears to have had but little literary aptitude, for the only publication bearing his name is a small quarto on the *Form of Animals*, issued in 1805, and reprinted in 1806 and 1809. It seems to be a matter of uncertainty whether ' Cline's splints ' for the treatment of fractures of the leg were employed by Henry Cline or by his son. Savigny's *Collection of Engravings representing the Most Modern and Approved Instruments used in the Practice of Surgery* was

issued in 1798. Plate IV, *Fig.* 3, shows "the cutting gorget of Mr. Cline, an instrument held in universal estimation." There is also a figure of a papier-mâché splint, which is attributed to Mr. Sharp. This splint is identical in shape with that which is known to us as 'Cline's,' even to the open angle at which the foot-piece is moulded. It is probable, therefore, that either Cline *père* or *fils* used this pattern of splint, made in wood instead of the more brittle papier-mâché, and that it thus obtained its name.

Of the younger Cline there is not much to record. He was born on Feb. 4, 1781, and was admitted to Mrchant Taylors' School at the end of 1791. In 1813 he was lecturing on anatomy at St. Thomas's Hospital jointly with (Sir) Astley Cooper, having succeeded his father as surgeon in 1812. Mr. South says of him, that he was "tall, sickly, and a very plain man, marked with smallpox, and very shy; but when he spoke his smile was most pleasing and agreeable; he wore powder, as was then the general custom; but his hair was most oddly dressed, a sort of *toupet*, with longish hair combed down straight and matted with pomatum and powder. An old friend of mine used to say he looked as if he had put his head in the dripping-pan on one side and the flour-tub on the other, but the simile would have been more correct had he said his hair had been well plastered down with butter and powder or with oxide of zinc ointment." He appeared at lecture in short knee-breeches, black stockings, and a brown coat. Cline's lectures began with the muscles of the head, starting with the occipito-frontalis and then going on to the face.

The contrast between the younger Cline and Astley Cooper was very great; the joyous manner of the latter had no correspondence in the former. He went on in a quiet monotonous tone and very slowly until the day's allotment was completed. But from his lectures no one got out under an hour and a half and sometimes even three-quarters. In the wards he was extremely kind to his patients. Both by example and authority he insisted on almost womanly tenderness in handling them, and carefully attended to little matters which added greatly to the patients' comforts, but by most others were regarded as too trivial to call for attention. He was a very good mechanic, but as an operator he was intolerably slow, for he thought that an operation ought to be done well, and did not much care how much time he spent in doing it. In private life Cline made himself beloved and respected by all who came into relation with him. He died of phthisis on May 27, 1820.

The bust by Chantry was presented to the elder Cline in 1811 by the subscription of his pupils. It was placed in the Museum of St. Thomas's Hospital, but now stands in the Central Hall of the present Hospital. There is a replica at the Royal College of Surgeons of England.

A CASE OF CONTUSION OF THE AXILLARY ARTERY.

By Lieutenant-Colonel J. F. DOBSON, R.A.M.C. (T.),
and Captain W. R. HIGGINS, R.A.M.C. (T.)

The case described below is an illustration of a type of arterial injury which is not often noted, but which is perhaps more common than is thought.

Pte. C. J. was wounded on Aug. 17, 1917, by a rifle bullet. He was admitted to a general hospital in France on Aug. 18, having received no active treatment.

The wound of entry was one inch below the middle of the left clavicle; the exit at the axillary border of the scapula, about the junction of the middle and lower third. Wrist-drop was present. The left radial pulse was smaller than the right. There was no swelling in the axilla; no bruit or thrill; no pulsation; no hæmorrhage. The entrance wound was clean, and the exit wound ragged. He bled freely when wounded, but did not faint. He noticed wrist-drop, and weakness and numbness of the hand immediately. Anæsthesia was incomplete in the ulnar and radial areas; the median was unaffected. Motor paralysis was present in the extensors of wrist and fingers; there was complete paralysis of the intrinsic muscles of the hand supplied by the ulnar, and weakness of those supplied by the median.

It was thought that the axillary artery had been damaged, if not severed, and that the inner and posterior cords of the brachial plexus had been lacerated.

Operation, Aug. 19.—The wounds of entrance and exit were excised. Some tearing of the scapular muscles was found. A curved incision (*Fig.* 1) was made from below the clavicle over the inner part of the pectoral muscles to the anterior fold of the axilla, thence passing outwards along the fold to the arm. A flap of skin was turned back. The pectoralis major muscle was divided close to its origin and turned outwards, exposing the pectoralis minor. This muscle was also divided close to the chest wall, and reflected. The axillary contents were now clearly exposed. Some extravasated blood was wiped away.

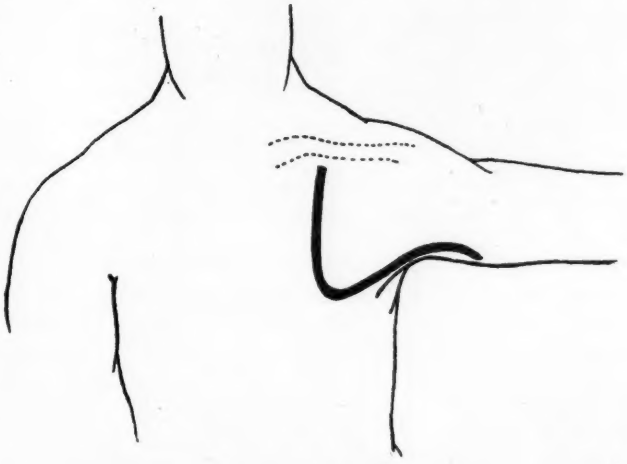


FIG. 1.—Diagram showing incision.

Axillary Artery.—At a point immediately above the crossing of the inner head of the median nerve, the artery presented a slight bulging, and appeared to be bruised. The artery was pulsating below this point, but on palpation of the damaged portion, the wall of the vessel felt thin, and after it had been handled a very slight weeping of blood occurred. The artery was ligatured above and below, and the damaged portion excised.

Brachial Plexus.—The inner cord, just above the point of division, had been partially divided by the missile. The posterior cord had been perforated by the missile, and was practically completely divided, the continuity of the nerve being maintained in part by the sheath. Both cords were repaired by suture of the sheath (00 catgut). The suture lines were covered with fatty fascial flaps taken from the lower part of the axilla.

The pectoral muscles were sutured, the axilla and exit wound were drained, and the entrance wound was left open. Both the wounds were swabbed with eusol, the axilla with saline.

Aug. 19.—Evening temperature 101°. Pulse felt at wrist.
Aug. 20.—Morning temperature 100°; evening temperature 101°. Pulse stronger.
Aug. 21.—Morning temperature 100°; evening temperature 100°.
Aug. 22.—Morning temperature 98·4°.

FIG. 2.—Open end of the resected portion of the artery, showing the laceration

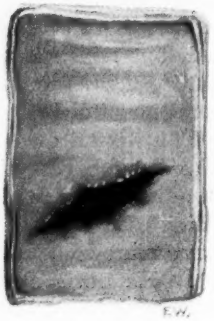


FIG. 3.—Appearance of the tear after slitting up the artery.

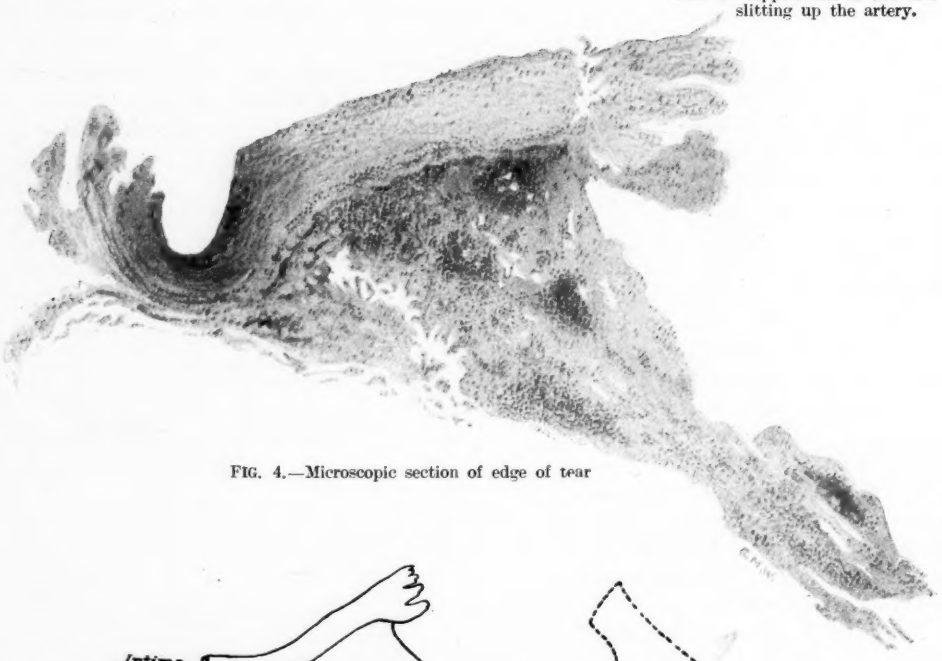


FIG. 4.—Microscopic section of edge of tear

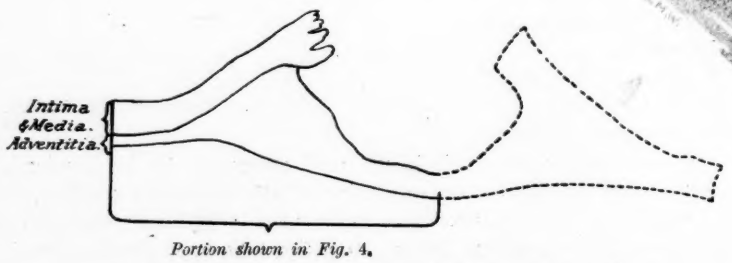


FIG. 5.—Section taken transversely across the tear in the vessel wall.

The patient made an uninterrupted recovery, and was evacuated to England on Aug. 31. There was already some return of power in the extensors of the wrist. We have since heard that he is making good progress.

Specimen.—On examination, the specimen was seen to consist of three-quarters of an inch of the axillary artery, which was patent. On looking into the open end of the artery a tear of the inner coats could be seen, with the turned-up edges of the tear projecting into the lumen of the vessel and partially occluding it. After slitting up the vessel, the laceration was seen to involve about three-quarters of its inner circumference, and to extend through the inner and middle coats. The outer coat of the vessel was exposed in the floor of the laceration, covered with a thin layer of clot (*Figs.* 2, 3). *Figs.* 4 and 5 show a longitudinal section taken across the torn part of the vessel.

Captain M. J. Stewart made a section of the artery and gave the following histological report :—

> Microscopically, the tear is found to extend completely through the inner and middle coats of the vessel, the 'floor' being composed of the tunica adventitia, together with a certain amount of adherent thrombus. The torn edges of the tunica media and tunica intima project inwards into the lumen of the vessel, while the 'floor' of the tear bulges slightly outwards.
>
> There is a certain amount of separation of the media and adventitia at each side, and the angle thus formed is occupied by a mixture of recent blood-clot and fairly dense thrombus. The process is similar to that of a dissecting aneurysm in an early stage. The adventitial floor of the tear is much disorganized and infiltrated with blood, and altogether looks very insecure.

It is evident that the bullet had passed obliquely through the axilla, just damaging the inner cord of the brachial plexus, pushing the artery aside—the impact causing the fracture of the inner and middle coats—and then severing the posterior cord. Free bleeding occurred immediately after the injury, but it quickly ceased, and one cannot say with certainty whether it came from the main artery or from the damaged vessels of the scapular muscles.

Examples of partial laceration of the large vessels are not commonly seen. Delorme (quoted by Sencert[1]) described three degrees of contusions of arteries. In the first degree the inner coat only is damaged, and on opening the vessel fine linear scratches are seen such as might be produced by the point of a pin. In the second degree the inner and middle coats are torn, though the tear does not extend around the whole circumference of the vessel. In the third degree there is a circular tear through the inner and middle coats, with retraction of these layers. The specimen described above is an example of an injury of the second degree.

In considering whether the right procedure was followed in operating on this case so soon after the wound and on apparently somewhat insufficient grounds, one has to consider what would have happened to the damaged artery.

It is certain that some thrombosis would have taken place. This might have been partial, and it is conceivable that the tear would have healed without occluding the lumen of the artery, leaving a scar at the point of injury ; at some later date this might have occasioned the formation of an aneurysm. Fragments of the clot might have become detached and caused embolism in the vessels below. The artery might have been completely occluded with clot at the seat of injury ; in the absence of sepsis this would have organized and the vessel would have become obliterated ; one of us (J. F. D.) has met with an obliterated axillary artery twice during operations undertaken many months after the injury for lesions of the brachial plexus. It is possible that thrombosis might have spread upwards and downwards, obliterating the collateral channels, and giving rise to gangrene, as described by Sir George Makins.[2]

These do not seem, however, to be the most likely occurrences. Secondary hæmorrhage, or the formation of an arterial hæmatoma, is more probable. In this case the wound of entry was clean, but the wound of exit was rather ragged and dirty, and there was some laceration of the scapular muscles. Some degree of sepsis was very likely to occur, and if this had spread to the neighbourhood of the damaged vessel it would eventually have given way. If hæmorrhage or a rapidly increasing hæmatoma had resulted, an urgent operation would have been required, and it is unlikely that the immediate repair of the divided nerves would have been possible, particularly if the patient had lost any quantity

of blood. Even in the absence of sepsis, any rise in blood-pressure might easily have determined a hæmorrhage. The gentlest manipulation of the exposed artery during the operation provoked a little weeping of blood.

It may be asked why the damaged artery was not repaired by suture. In the first place, it was thought that the vessel might be contused for some distance, and that it would therefore be unsuitable for suture; secondly, ligature and excision of the damaged portion of the artery gave easy access to the divided posterior cord. The need for suture of the axillary artery does not seem to be demonstrated in such a case as this. Gangrene is practically an unknown event after ligature, in the absence of serious infection or gross injury to the tissues of the limb.

If it is conceded that similar cases to this should be explored, on what grounds can the injury be diagnosed? It will be noted that the patient was said to have bled freely immediately he was wounded. It is difficult to know whether this arose from the axillary artery itself or from other vessels. It seems almost inconceivable that the artery could have bled very freely and still have presented the appearance it did when exposed. On the other hand, though there was little internal clot, there was some extra-arterial clot, and the pressure of this may have checked the hæmorrhage. The only other symptom of arterial injury was a slight but definite diminution in the pulse on the affected side.

The nerve injury in this case was an additional reason for interfering, though it is usually not wise to repair nerves until the original wounds are healed.

The incision used is one which gives admirable access to all the structures in the axilla, with a minimum of damage to the pectoral muscles and their nerve supply. It is most useful in cases of injury to the brachial plexus when an operation is undertaken some months after the wound.

We desire to express our thanks to Colonel T. Gowans for permission to publish the record, and to Colonel Sir Alexander McCormick, A.M.S., for his advice and for the interest which he took in the case; also to Captain M. J. Stewart for the microscopic specimens.

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BONE GROWTH AND BONE REPAIR.*

By Professor ARTHUR KEITH, F.R.S.

LECTURE II.

RESEARCHES MADE BY SYME AND BY GOODSIR REGARDING THE GROWTH AND REPAIR OF BONES.

My last lecture closed with the death of Hunter in London in the autumn of 1793. We shall now proceed to Edinburgh, to see what two men who made Edinburgh famous in the middle decades of last century—Syme the surgeon and Goodsir the anatomist—can teach us regarding the manner in which bones grow and heal. It suits our purpose, however, before proceeding to Edinburgh, to discover how bone surgery stood in the North of England during Hunter's time.

No one who values a knowledge of the history of surgery and of learning in England can afford to be ignorant of Charles White of Manchester. He was born in the same year as Hunter, 1728; he was a class-fellow of his in the Covent Garden School; through his long life he never wavered in his loyalty to Hunter's splendid abilities. He was elected a Fellow of the Royal Society long before Hunter. Cullingworth has assigned to him a foremost place amongst British gynæcologists; Cunningham has given him equal rank amongst the pioneers of British anthropology. He took a leading part in founding the hospitals, colleges, and learned societies of his native city, Manchester.

We propose to make his acquaintance in April, 1768, when Edmond Pollet, a country lad of fourteen, presented himself at Manchester Infirmary with an abscess in the left shoulder, the disease having commenced suddenly a fortnight previously. Pus was issuing by several sinuses situated in the pectoral and deltoid regions. If Charles White, then in the prime of his professional career, had followed the standard treatment of the period, he would have amputated the arm; but he resolved to try and save the limb by adopting a novel and conservative method of treatment. Making a deep vertical incision along the deltoid region, he forced the upper end of the dead shaft of the humerus from the wound and cut it off. Later, a further piece of the shaft was removed—altogether four inches of it. The arm was placed in a sling, so that "the weight of the arm might counterbalance the contraction of the shoulder muscles." Movement was permitted, to secure a sufficient degree of mobility at the shoulder-joint. In four months, to Charles White's surprise, the upper end of the humerus had been reproduced; there was only one inch of shortening, and the arm could be freely used. In reporting this case to the Royal Society in 1769, White drew two conclusions: (1) That when a bone was removed, the arteries of the part had the power to renew it; (2) That the operation of resection had manifest advantages over amputation, and deserved serious consideration as an alternative measure.

Charles White's novel operation of 1768 merely involved the resection of dead bone. In 1783, Mr. Henry Park, surgeon to the Liverpool Infirmary, was in a position to announce a further stage in the progress of surgery—the possibility of excising diseased joints as an alternative to the amputation of limbs. We merely note here that each of these innovations in the treatment of diseased bones and joints demanded a more intimate and exact knowledge of the life and growth of bone.

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* Three lectures of a course on "Anatomical and Physiological Principles underlying the Treatment of Injuries to Muscles, Joints, and Bones," delivered at the Royal College of Surgeons, England.

Having thus seen the rise of 'conservative surgery' in the North of England in the later half of the eighteenth century, we pass on to Edinburgh to watch the practice and principles of James Syme. In his day Syme held the centre of the surgical stage; but it is only the early part of his career which interests us now—the struggling decade between 1823 and 1833, from his twenty-fourth to thirty-fourth year, when he was forcing his way up the Edinburgh surgical ladder. In 1825 there was sent to him a woman, Christian Laing, age 38, who had suffered from caries (tuberculosis) of the shoulder-joint for six years. Syme was brought face to face with the same problem as had been presented to Charles White fifty-seven years before—should he amputate, or should he resect the joint and thus try to save the limb? He chose the latter, and the woman did well. Resection as a defined operation for the relief of a diseased joint, was, as we have seen, first formulated in 1783 by Henry Park, surgeon to the Liverpool Infirmary, in a letter to Percival Pott; but the suggestion which moved Syme to adopt the operation came from a French source. Almost at the same time as Park was elaborating and applying the operation of resection to joints in Liverpool, Moreau, a surgeon in the North-East of France, was adopting a similar method of treatment, though it was many years later (1816) before his French colleagues recognized the value of his work. The first effort of Syme's youthful career was to introduce this operation into Scotland. In 1831 he published a *Treatise on the Excision of Diseased Joints.* By that date he had done fourteen resections of the elbow-joint. The introduction of a new surgical method invariably makes new demands on our knowledge of anatomy and physiology. The adoption of resection of joints as a routine measure made an exact knowledge of bone reproduction more urgent than ever.

If we would use words in a strictly conventional sense, we must describe Syme as eminently a practical as well as a daring surgeon. To the onlooker he seemed to apply a remarkably sound, common-sense judgement to the various surgical problems which came before him. In reality he was, as all purely practical men must be, an experimental surgeon, trying to discover the best means of treatment by roughly balancing the results which attended one method against those which followed from another. But for one brief period in his life Syme became a rational surgeon. In 1835—two years after he succeeded to the chair of clinical surgery in Edinburgh University—he had to treat the case of a young girl who suffered from acute osteomyelitis of the tibia. He had to amputate. When he dissected the leg, he found the shaft of the bone dead, and enclosed by a new stratum of bone which was adherent to, and apparently formed by, the periosteum. To settle for all time that periosteum could and did reproduce bone, he carried out the following well-devised—and, I have no doubt, neatly executed—experiment on young dogs.

In his first experiment he removed 1¾ in. from the radius of both right and left legs; on the right he also removed the periosteum, whereas on the left this membrane was preserved in place. When the dog was killed at the end of six weeks, the missing part of the left radius was reproduced; whereas, on the right, where the periosteum had not been preserved, a gap still remained. He repeated the experiment on a second dog, and got the same result: when the periosteum was removed, a gap remained.

He changed the conditions of the experiment. Taking another dog, he raised the periosteum from a segment of the radial shaft, and separated the periosteum from the bone by introducing between them a ferrule of tin-foil. The periosteum formed a layer of bone on the tin-foil.

Finally, he cut away the periosteum from a segment of the radius, and wrapped the denuded surface with tin-foil. No layer of bone was deposited on the tin-foil, because there was no periosteum covering it.

We have here the Haller-Duhamel controversy again raised, and it is clear Syme became a convinced Duhamelite.

We are now to make the acquaintance of a man who in his intimate and deep grasp of the problems presented by living matter came nearer to Hunter than any other Briton of the nineteenth century. In physical appearance John Hunter and John Goodsir were as different as men can be. Hunter was from the West, of medium stature, alert and fiery; Goodsir was from the East—from Anstruther in the county of Fife—tall, gaunt,

serious, and Calvinistic, with a long, sombre countenance. But Hunter and Goodsir were alike in this: they had an insatiable capacity for work, and an almost 'uncanny' gift of rightly interpreting, from the slenderest of clues, the more secret workings of living matter.

Here, however, we have to do only with Goodsir's investigations concerning the growth and reproduction of bone. Goodsir knew well about Syme's researches into the reproduction of bone by periosteum; he had 'dressed' for Syme; he was a student in Edinburgh and apprenticed to Nasmyth the dentist when Syme was rising to the height of his fame. There was every inducement for him to support Syme's conclusions; but the result of his investigations convinced him that the periosteum had no power to form bone, and that there was only one element in the body which could form and reproduce bone—namely, the corpuscles, which he had discovered and studied with his microscope as normal constituents in every variety of ossification. Goodsir was a Hallerite of a new kind.

No one can serve so well as Goodsir to bring home to us the transformation which took place in our knowledge of living bone in the decade which followed 1838—when men first came to realize that living matter is made up of units or atoms to which we give the name of cells or corpuscles. We are pursuing a straight path when we lay bare the circumstances which made Goodsir one of the pioneers of the cell doctrine. There are, in the first place, the circumstances of his training. He came of a line of medical practitioners. At the age of sixteen—in 1830—he was apprenticed to Nasmyth the dentist. He had the most delicate control of his long fingers, and very soon began to apply his manipulative ability to the investigation of tooth formation—which entailed a collateral study of bone growth. In Knox's dissecting-room he was thrown amongst the men who were to be leaders in science and in medicine—Edward Forbes, Fergusson, John Reid, and Sharpey. He dressed for Syme and dissected for Alison. In 1835 he became a Licentiate of the College of Surgeons of Edinburgh, and returned to Anstruther to assist his father. In three years he was back in Edinburgh in search of a foothold on the ladder which led to the more eminent posts in medicine. He had to wait until 1841, when he was twenty-seven years of age, before one came—the curatorship of the Museum of the College of Surgeons, at a salary of £150 per annum, out of which he had to pay an assistant. He only held the office for three years; but never did man crowd years with discoveries as Goodsir did these three. They were discoveries, we shall see, that have a very direct bearing on the problems we are exploring.

Goodsir brought to his office not only rare powers of brain and hand, but two qualifications which are absolutely essential for the man who would open a new field of knowledge—a new instrument and a fresh inspiration. The new instrument was the compound achromatic microscope, which had then been perfected by Lord Lister's father, and was Goodsir's companion from his boyhood upwards. His inspiration he drew from years spent in the study of the marine forms of invertebrate life which he dredged from the waters of the Firth of Forth. Molluscs, echinoderms, and sponges presented him with the same problems of life as did the tissues of the human body, but in a simpler form. He had the means of spanning the gap which seems to separate the hydra from the human body with much greater accuracy than was possible in Hunter's time. When he came to unravel the obscure and complex process of bone-building in the human skeleton, he found the clue from his work on sponges; they also build skeletons.

Goodsir was a follower of Hunter. In his youth he accepted Hunter's teaching that bone was deposited by arteries and was absorbed and remodelled by lymphatics. His microscopical investigations of the growing epiphyseal lines of bones revealed cartilage cells grouping themselves into serried ranks; he saw, or thought that he saw, these cartilage cells settle in the meshes of the cartilaginous trabeculæ and become "bone-forming corpuscles"; he traced the transformation of the primary spaces in the cartilage from one stage to another until they became Haversian canals, still lined by the cells which he regarded as the descendants of the primitive cartilage corpuscles. He saw how the corpuscles of the Haversian canals became included within the bone to become its living denizens. He knew that similar cells built up the skeletons of invertebrate forms

of life, and had no doubt that the human skeleton was laid down, not by arteries, but by an element of which Hunter had no conception—separate self-acting units of living matter. That discovery—Goodsir made it for himself, others had done the same independently—marks a new chapter in our knowledge of bone. But the old or Hunterian chapter did not pass out of date; the new chapter merely gave a more precise interpretation of the facts contained in the old. Bone corpuscles were substituted for arteries.

There were in the Museum of the Edinburgh College, under Goodsir's care, certain famous specimens which had been made in William Hunter's school in London by Cruickshank. They were supposed to demonstrate that lacteals opened on the intestinal villi by open mouths. Goodsir applied his microscope to these specimens; he could see the injected lacteals in the villi, but nowhere could he find openings or mouths. He applied himself to the problem of absorption. He fed a dog, and when digestion was at its height, examined the villi. He found cells laden with the products of digestion, and concluded that the cells which line the bowel were the agents by which food was taken up and absorbed from the contents of the intestinal tract. His intimate knowledge of cellular processes in the lower forms of life led him further; he realized that every cell in the human body must have a power of absorption. Absorption was a natural function of every kind of cell—including those which are found in bone. Thus, he had to throw overboard Hunter's conception of lymphatic vessels playing the part of bone absorbers and bone modellers, and put in their place simple units of living matter—bone cells.

The microscope revolutionized, and at the same time simplified, our conception of the growth, maintenance, and reproduction of bone. In place of it being a living tissue manipulated by arteries and by lymphatics, it became an organization of living units—bone corpuscles—each of them endowed with the power to build up or take down that territory which lay directly under its control. Goodsir was the first to realize the new picture of bone. That discovery has not made Hunter's assumption of 'consciousness' in bone less tenable. How are such cells controlled? What are the circumstances which make them lay down bone on one day and carry it away on the next?

The investigations which Goodsir made on the nature of bone, during the three years of his curatorship, are recorded in four very brief papers which first appeared in his *Anatomical and Pathological Observations*, published in 1845.* One of these is entitled, "The Mode of Reproduction after Death of the Shaft of a Long Bone." It is an inquiry concerning the bone-forming power of periosteum—being an answer to Syme's investigations mentioned in an earlier part of this lecture. He concluded that periosteum has no bone-forming power—it is simply, as he terms it, a 'limiting membrane.' He did not deny that periosteum "participated in the office of regeneration—an important principle in surgery," but its power to form bone depended wholly on the proper substance of the shaft which had become adherent to it. By actual experiment he removed periosteum by scraping, and found particles of bone adhering to its deep surface. From such fragments, he concluded, new bone was reproduced. He examined the periosteal shells which form round necrosed shafts. He found that wherever there was a rough or ulcerated patch on the old shaft, there was also in the corresponding area of the periosteum a nucleus of bone growth; but where the areas of the old shaft were perfectly smooth—where there was no trace of exfoliation or ulceration—there was a gap or cloaca in the overlying periosteal shell. If the periosteum owed all its osteogenetic power to adherent morsels of bone, then these appearances were just as they should be. He conceived that the shaft of a bone might be killed so quickly by disease that there was no time for the separation of living fragments to act as bone grafts on the periosteum. In such a case there would be no reproduction of bone. If the greater part of a shaft did die, he observed that ossific centres shot out most vigorously from the terminal living parts. He had never seen an epiphysis take any part in the regeneration of a shaft; in a physiological sense an epiphysis should be regarded as a separate bone. Finally, as regards Syme's experiments,

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* See *The Anatomical Memoirs of John Goodsir*, by William Turner, Vol. ii., 1868.

Goodsir held that they did not demonstrate an osteogenetic power in periosteum, but they did demonstrate that, as detached by the surgeon, it could and did carry with it bone grafts which could serve as centres of reproduction. For Goodsir, a bone was a hive of bone corpuscles wrapped within a nest of periosteum.

I have mentioned Hunter's graphic and accurate picture of what the unaided eye can see when a living bone casts off a dead piece. Goodsir's paper on "Absorption, Ulceration, and the Structures engaged in these Processes" adds a fitting pendant to Hunter's picture—a pendant painted through his microscope—the earliest picture of its kind. We have seen that Goodsir recognized the corpuscles which lined the walls of the Haversian canals as the oldest and most active of the cellular constituents of bone. He had observed them on the surface of the bone, under the periosteum. He knew well that these canalicular cells could be stimulated to activity by inflammation; in Hunter's phraseology, they were endowed with irritability. He saw, in an inflammatory area of bone, that these cells multiplied in the Haversian canals; the walls of the canal widened by the proliferation of tissue and the absorption of the wall until neighbouring Haversian systems almost met, or did fully meet. He saw no impossibility in the cells which laid down bone changing their mode of life and devoting themselves to clearing away their old handiwork. He conceived that the more active these bone-devouring cells were, the shorter would be the term of their lives, and the sooner would they melt and their remains pass into the general circulation. By the proliferation of the cells in the canalicular systems an area of dead bone was separated from the surrounding living bone. The microscope simplified the understanding of the effects of inflammation on bone: Goodsir was the first to realize that these changes were effected by living units or cells.

Goodsir's bone researches were all carried out in the three years of his curatorship. In 1846, at the age of thirty-two, he was elected to the chair of Anatomy in the University of Edinburgh in succession to the third Monro. Just before the onset of his long, disastrous, and drawn-out illness, some ten years later, he opened up a field of research which yet remains to be explored. It is one which is destined to throw a new light on the living qualities of bone corpuscles. In 1853 a pupil had sent him a new form of sponge dredged from the waters off Spitzbergen. While investigating its structure, he observed that the spicules—its skeleton—had many forms, but each was built and laid down so as to strengthen and keep open the water-canals on the entirety of which the lives of the sponge colonists depend. He looked for the builders and found them. No one had seen or studied them before. He formulated the following law: "A spiculum is formed by a series of sponge-particles (sponge cells), so arranged in a column or system as, by the silicification of more or less of their contiguous surfaces and substance, to form a continuous rod." In short, he saw groups of spicule-forming cells marshall themselves into a geometrical pattern and lay down supports of the exact form and in the exact position where such supports were needed. We shall see that bone corpuscles have also similar qualities.

During the last ten years, Professor Dendy,* of King's College, London, and his former pupil, Professor Woodland,† have carried out a series of researches which justifies one in regarding the scleroblasts which form the spicular skeletons of invertebrate forms of life as the exact counterparts of the osteoblasts of our own bodies. In the more primitive types a spicule is actually formed inside the cell—an intracellular secretion; all stages between the intracellular and extracellular mode of spicular formation can be demonstrated. The scleroblasts are special cells derived from the dermal layer. They do their work according to the needs of the animal frame of which they form part; they build their spicules so as to strengthen that side of a sponge which is exposed to the force of the waves, just as osteoblasts built to withstand the pressures applied to bone. The scleroblasts, Professor Dendy observed, are sensitive to vibrations.

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* For Professor Dendy's latest paper, see *Proc. Roy. Soc.*, 1917, lxxxix, 573.

† *Quart. Jour. Microscop. Sci.*, 1905, xlix, 231; 1906, xlix, 533.

OBSERVATIONS ON BLADDER INJURY IN WARFARE.

A STUDY OF 53 CASES.

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The word 'injury' has been chosen in the title of this paper, to include several cases which would not come under the heading of 'gunshot wounds.' A case of rupture of the bladder due to the falling-in of a dug-out, and two cases of bayonet wound, are thus included. Wounds of the bladder are comparatively rare. The percentage to total wounds reaching the base is probably not more than 1 in 3000 or 4000. For this reason it has taken some time to collect sufficient material to warrant the publication of this article.

The present communication is based upon a study of 53 cases. A few of these were seen at clearing stations, but the remarks which follow deal with the subject from the point of view of a surgeon working at the base. The very severe injuries which die at the aid posts, at the field ambulance dressing stations, and at the clearing stations, are therefore excluded. The final results are, unfortunately, not known in a considerable proportion of the cases, but enough material has been obtained to bring out the main points in the recognition and management of these injuries at a stage anterior to their evacuation to England.

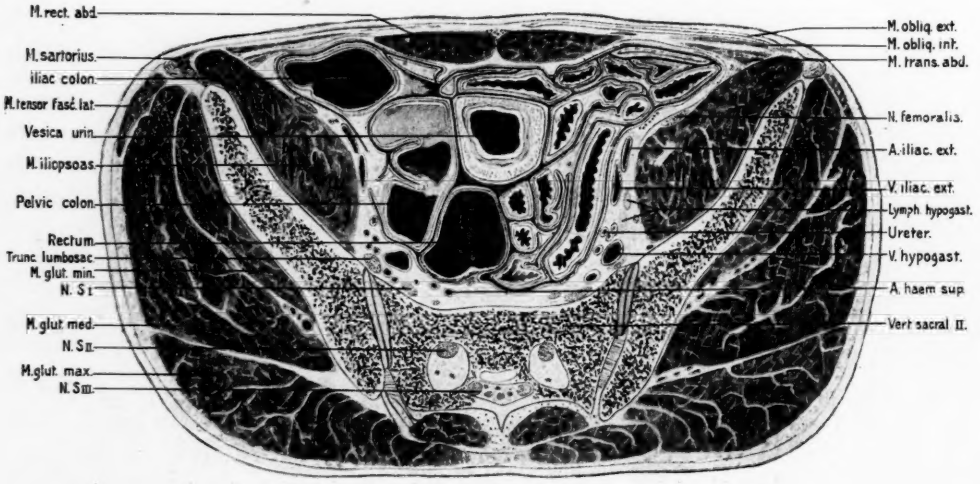


FIG. 6.—Upper surface of *Slab XIX* (Man 50). Note the small intestines lying anterior to the distended bladder. (×⅓.) (*Crymble.*)

Anatomy.—It is unnecessary to describe the anatomy of the bladder in detail, but there are certain points which have an important bearing on the subject under discussion that may with advantage be brought to mind. In the collapsed state the bladder is a strictly pelvic organ, and occupies so little space that it forms a very small target for the missiles of war. When empty, it lies deeply in the pelvis, and, in a vertical antero-posterior section, is triangular in shape, being flattened above and below. When moderately distended, it still remains a pelvic organ. When fully distended, however, it becomes at its upper part an abdominal organ, and is likely to be injured by missiles entering above the

pubis. Occasionally coils of small intestine lie in front of the distended bladder, and may be injured by missiles entering the latter in this region (*Fig.* 6). It is reasonable to suppose that just before an attack the state of nervous tension practically always present will lead to an evacuation of the bladder contents; whereas, if the patient is caught unawares

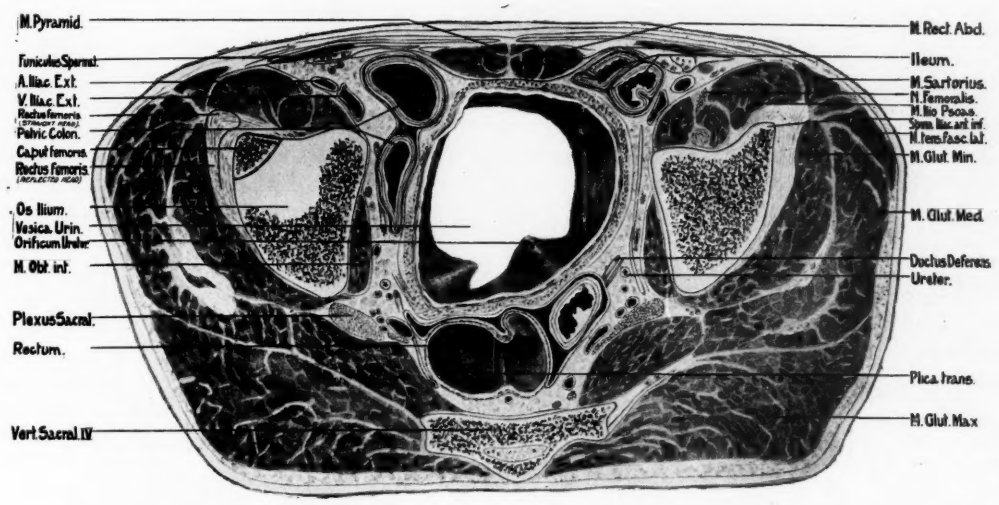


FIG. 7.—Upper surface of *Slab XX* (Man 50). Bladder distended. (×¼.) (*Crymble.*)

at other times, the organ may be in any state of distention. The *anterior* or *pubic surface* lies against the symphysis and body of the pubis and the deep layer of the triangular ligament. Only when the bladder is fully distended does this surface reach the lower part of the anterior abdominal wall. The space of Retzius lies anterior to the bladder, but

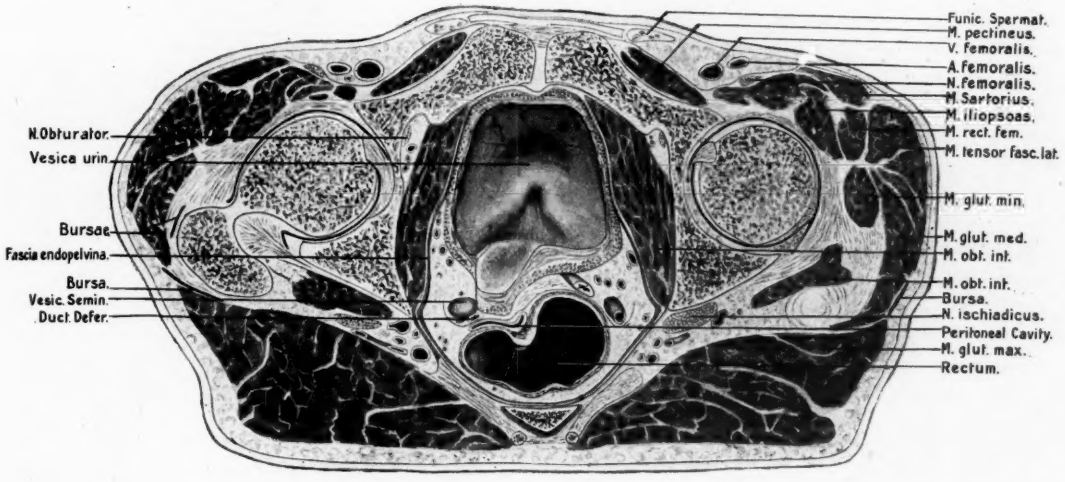


FIG. 8.—Upper surface of *Slab XXI* (Man 50). This section passed through the hip-joint, rectum, and base of the bladder. (×¼.) (*Crymble.*)

communicates freely with a similar space which extends laterally and backwards, internal to the levator ani muscle, to the posterior part of the rectum (*Fig.* 8). This fact has an important bearing on the question of extravasation of urine and the spread of pelvic cellulitis. The *base* of the bladder is its widest part. It lies against the rectum, and is

adherent to the bowel by dense areolar tissue, except for a short space above, where it is separated from this portion of the intestine by the reflection of the peritoneum at the lower part of the rectovesical pouch. This area of close apposition is bounded by the vesiculæ seminales and ejaculatory ducts of either side, which form a triangle with its apex at the prostate gland (*Fig.* 8). The sides of the bladder are crossed by the cord of the obliterated hypogastric artery, which marks the lower limit of the peritoneal reflection. All the area below this mark is extra-peritoneal (see *Fig.* 24). It is well to remember that the ureter and the vas deferens are in relation to the sides of the bladder, and the possibility of their injury in this situation must be borne in mind (*Fig.* 7). The *superior* or *abdominal* surface is free, and covered everywhere by peritoneum.

The prostate is so intimately connected with the neck of the bladder that it is frequently injured with it (*Fig.* 9). The gland rests posteriorly on the rectum at the point where it turns back to become the anal canal. Anteriorly it is half an inch or more from the pubic symphysis. The sides are embraced by the anterior fibres of the levatores ani. The apex rests on the upper surface of the triangular ligament.

The arrangement of the pelvic fascia is shown in the accompanying drawings.

The Missile.—In 1 case a missile (shell) was only indirectly responsible for an intraperitoneal rupture of the bladder ; the injury was caused by a fall of earth on the abdomen.

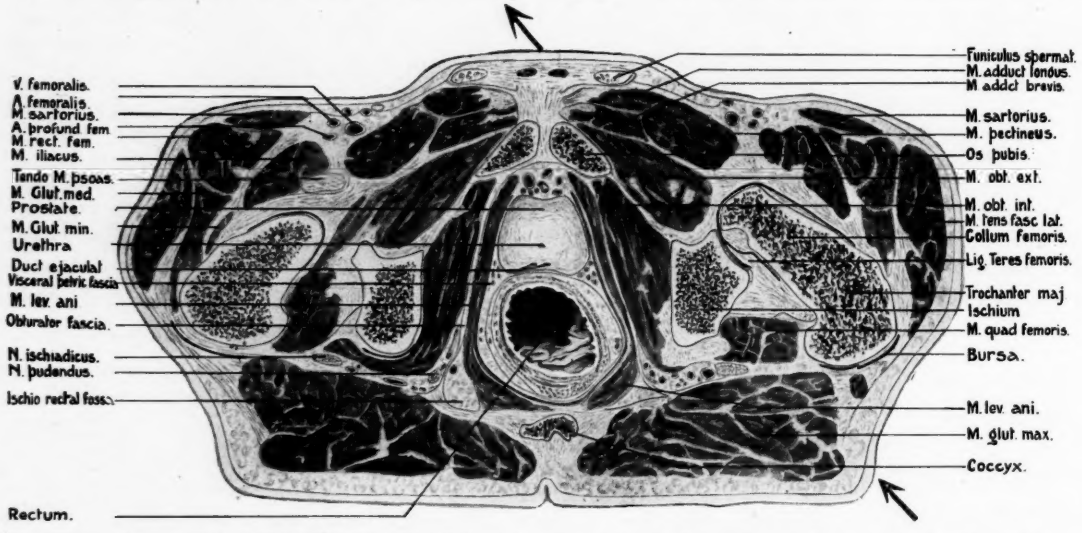


FIG. 9.—Upper surface of *Slab XXII* (Man 50). This section passed through the prostate and rectum. (×¼.) (*Crymble.*)

In 2 cases the injuries were caused by bayonet. In 24 cases the wound was caused by shell (including bomb, grenade, etc.) ; in 12 by bullet (rifle or machine-gun) ; in 7 by shrapnel ball. In 7 cases the nature of the missile was not stated.

Although wounds by shell are liable to be more serious, and to be attended with greater risk from sepsis, than those caused by bullet, the wounds by the latter were often very severe and septic. Of the fatal cases, 5 died of shell wounds, and 4 of bullet wounds, while death was due to a shrapnel-ball wound in 1 case ; in 2 fatal cases the nature of the missile was not known.

Track of the Missile.—In about two-thirds (34) of the cases the missile reached the bladder by way of the buttock. In 5 others there was an exit wound in the region of the buttock, communicating with the bladder. In nearly 75 per cent, therefore, there was a wound in the buttock region reaching as far as, or actually penetrating, the bladder (*Fig.* 10). The suprapubic route was comparatively rare. There were 4 cases with an entry wound in this situation, and 4 others in which the missile had either emerged by this route or had been retained in the suprapubic region. Wounds in the anterior abdominal wall, not suprapubic in position, rarely implicated the bladder. In 4 cases only did the missile

reach the bladder through the anterior abdominal wall, and there were no exits in this region. Wounds which shatter the symphysis pubis and lay open the bladder rarely reach a base hospital. Other routes were through the thigh, the groin, the iliac region, the loin, and the sacral or coccygeal region. In one case a bayonet wound reached the bladder through the perineum.

There were 13 through - and - through wounds recorded in the notes. The majority of these followed an oblique course; several passed from buttock to suprapubic region, or in the opposite direction; another route was from iliac region to perineum, another from groin to buttock, and another from thigh to sacral region. Antero-posterior wounds were somewhat rare; their course was from suprapubic to sacral or coccygeal region, or in the opposite direction.

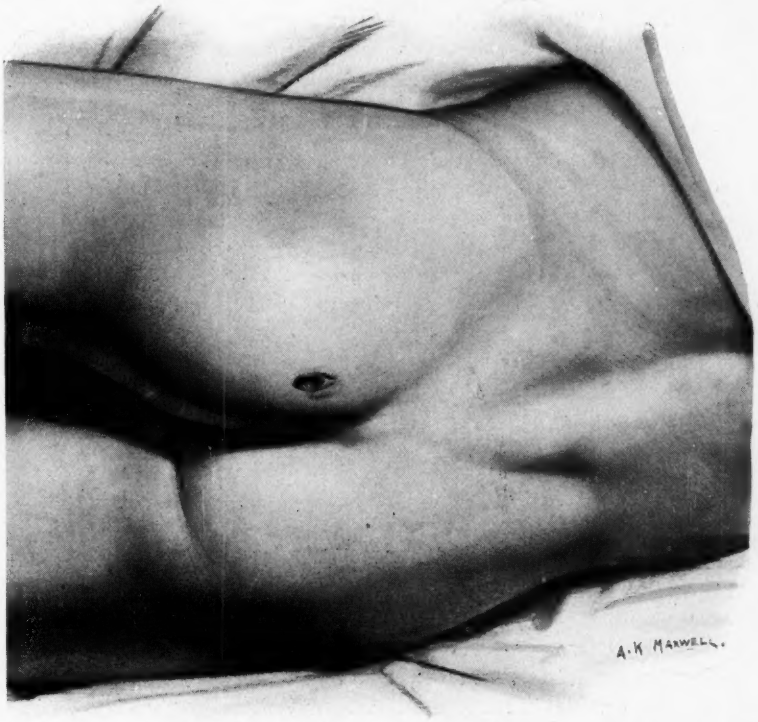


FIG. 10.—Buttock wound through which the large fragment of shell shown in *Fig.* 23 entered. From *Case* 53 (22b).

Transverse wounds were seen occasionally; these passed from buttock to the opposite side across the neighbourhood of the hip-joint, or from buttock to the opposite groin. In 5 cases it was impossible to say whether there had been an exit wound, or whether the opening found had been due to an operation undertaken to remove a foreign body.

FIG. 11.—Exit wound produced by a bullet which struck bone and dropped back into the bladder. Note the surrounding ecchymosis. From a case more recent than the present series.

Reconstruction of the Track.—Entrance wounds in the buttocks, suprapubic, sacral, or coccygeal regions, or in the thigh or groin, ought to be carefully investigated. If a wound of exit is present, reconstruction of the track by sectional anatomy may indicate whether it is likely to have involved the bladder or not. If a foreign body is retained and it can be located accurately by radiography, the track may be reconstructed from the entrance wound to its ascertained position. In this way it will often be possible to determine with a fair degree of accuracy what structures have been involved in the passage of the projectile. The accompanying cross-sections (*Figs.* 6–9) are taken from a paper by Mr. P. T. Crymble,[1] and I am indebted to

him for his kind permission to reproduce them. A glance at these will show what structures are likely to be injured by wounds such as have just been described.

Fate of the Missile.—The foreign body was retained in 33 cases. In 10 of these it came to rest in the bladder. In most of the remaining cases it lodged in the pelvis or its walls, occasionally between the bladder and rectum. In one case the foreign body lodged just outside the bladder wall, while in another it was found later by cystoscopy to be embedded in the wall, in process of ulcerating its way through. A missile, therefore, may reach the bladder and contuse it, without doing further damage, as in *Case* 1 ; it may lodge in its wall, as in *Case* 53 (22b) ; it may enter its cavity and remain there, as in the 10 cases referred to ; or it may make a second opening in the bladder and emerge, to lodge in the

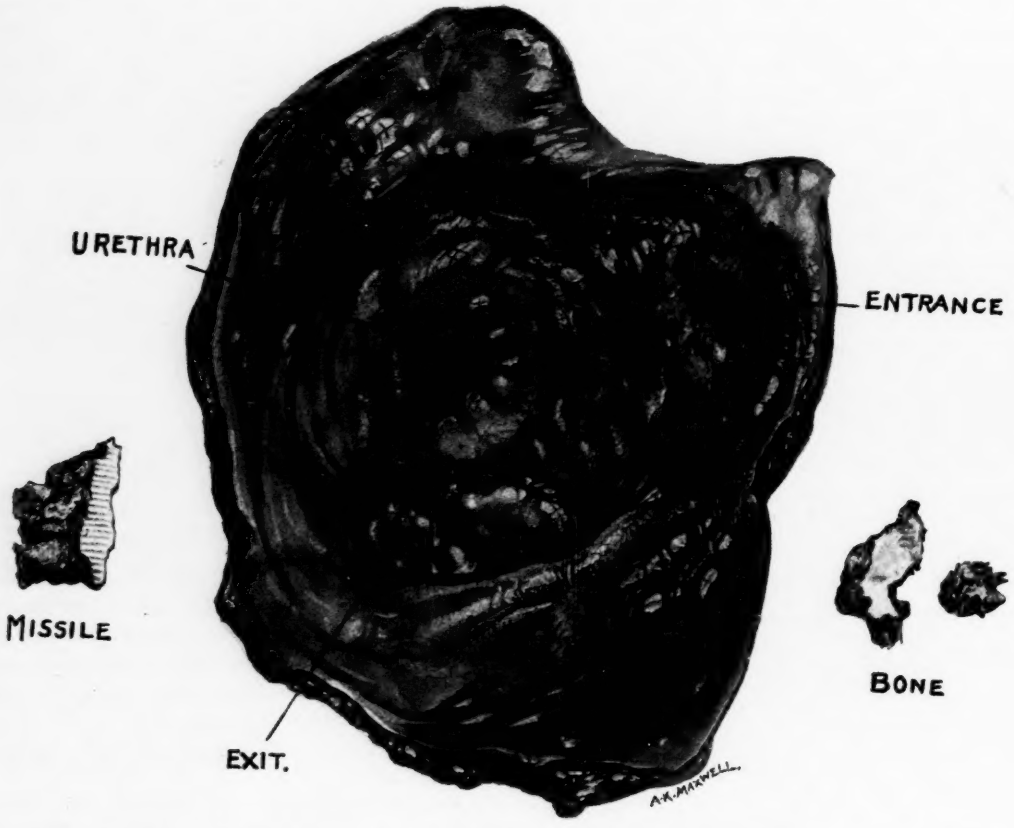


FIG. 12.—Through-and-through wound of bladder produced by shell fragment. The entrance wound is larger than the exit, probably on account of the in-driven bone being retained in the bladder. The exit wound involved the peritoneal cavity at the lower part of the rectovesical pouch, and communicated with the rectum. Note the ecchymosis of the bladder wall and the superficial necrosis of the mucous membrane. The missile had passed through the pubic bone, bladder, rectum, and sacrum, and lodged in the tissues behind. Death took place from gas infection in the track six days after injury. From a recent case.

pelvis or overlying soft parts, or to escape from the body altogether. In one case a bullet passed through the bladder but dropped back into it after striking bone—*Case* 13 (11a). In a few cases the wound was apparently tangential, the circumference of the bladder being injured at one spot only (see *Fig.* 15).

The Character of the Wounds.—The entrance wound, which, as has been stated, is often in the buttock, is frequently of small size and comparatively insignificant on superficial examination (*Fig.* 10). To reach the bladder a very considerable amount of tissue has to be traversed, and the length of the track may be six inches or more (*Figs.* 6–9). The more common large wounds of the buttock with which we are familiar frequently

stop short of the bladder. The bony girdle may arrest the missile before it reaches the depths of the pelvis, and the bladder may thus be spared. In the wounds under consideration, however, bone is often injured, and splinters may be driven into the bladder wall. The wound, therefore, is usually of the nature of a long fistula, the walls of which are often severely contused and liable to undergo a certain amount of necrosis. Along this track

FIG. 13.—Rectum from same case as *Fig.* 12. Note the ecchymosis of the rectal walls, and the ring of necrosis surrounding the wounds of entrance and exit; also the gangrenous condition of the peri-rectal tissues.

urine and sometimes fæces may reach the surface. The frequency and importance of bone and bowel injury will be dealt with later.

The wound in the bladder itself was of the most varied nature. Sometimes it was a perforation, sometimes a tear or a slit, and in one case a considerable portion of the bladder wall had been shot away. In pubic wounds involving bone, the last condition is likely to be present—*Case* 41 (10b). When there is a peritoneal wound of exit, as in *Case*

27 (25a), the peritoneal coat may be split for a longer distance than the remaining coats of the bladder wall. There is likely to be a good deal of ecchymosis of the damaged walls in the vicinity of the wound (*Fig.* 11), and for some distance around, and this has in a few cases been demonstrated by cystoscopy (see *Fig.* 21). A wound of the bladder may be intraperitoneal only, as in *Cases* 7 (5a) and 45 (14b), or it may be partly intraperitoneal and partly extraperitoneal, as in *Case* 40 (9b). When entrance and exit wounds exist, there may be both an intraperitoneal and an extraperitoneal opening (*Fig.* 12), as in *Cases* 8 (6a) (?), 13 (11a), 21 (19a), 27 (25a), 31 (29a), 36 (5b), and 52 (21b), or both wounds may be entirely extraperitoneal, as in the remaining cases. (The case of intraperitoneal rupture and the case of contusion only are excluded.)

Associated Injuries.—The gravity of injuries to the bladder is greatly enhanced by associated damage to adjacent structures. In the present series 35, or nearly 70 per cent, were complicated by injury to intestine or bone, or both. In 26 cases (50 per cent) there was a wound of some part of the lower intestinal tract, and 13 of these were also complicated by osseous fracture. There were 19 cases of damage to the rectum (*Fig.* 13); in 3 of these there was an intraperitoneal wound; in the remainder the wounds were extraperitoneal. In 6 cases the small intestine was wounded, and in several of these the damage was such as to require resection of considerable lengths of gut. In 1 case there was a superficial wound of the peritoneal and muscular coats of the pelvic colon. In 22 cases (42 per cent) there was damage to the bones of the pelvic girdle. The pubic bone was fractured in 12 cases, once in association with the sacrum, once with the great trochanter, and once with the head of the femur, involving the hip-joint. In 1 case the notes state that the bones entering into the formation of the obturator foramen were damaged. The sacrum was fractured in 5 cases, once in association with the pubic bone. The iliac bone was fractured in 2 cases, once in association with the ischium. The ischium alone was fractured in 1 case. In 2 cases the coccyx was fractured. It is possible that bone injury may have been more frequent, and that cases of fracture may have escaped notice, when it was not practicable to have recourse to radiography. Legueu[2] found fractures in 25 of his 43 cases of bladder injury (over 58 per cent).

Wounds in the region of the neck of the bladder are liable to be accompanied by damage to the prostate, and the notes mention this complication as having been present in 7 cases. This estimate may be incorrect, as injuries in this region are difficult to locate with accuracy. I have thought it well to include these 7 cases as injuries to the bladder rather than the urethra, as it was difficult to ascertain the exact extent of the damage.

Other complicating injuries were present as follows. The anterior crural nerve was injured in 1 case, the sciatic nerve in 2 cases, the femoral vein in 1 case, and the spine (concussion) in 1 case; involvement of the spermatic cord, necessitating orchidectomy, was present in 2 cases. The position of the vesiculæ seminales and ejaculatory ducts renders them liable to injury when the bladder and rectum are simultaneously involved (*Fig.* 8); only in a few cases, however, was a diagnosis of injury to these structures made. Injuries in other regions of the body were occasionally present, and contributed to the gravity of the case.

The more important combinations of bowel, bone, and bladder injury met with may be summarized as follows:—

Structures Injured	Cases
Bladder, pelvic bone, and rectum	11
,, ,, ,, small intestine ..	2
Bladder and pelvic bone	9
,, ,, rectum	8
,, ,, small intestine	4
,, ,, pelvic colon	1

SIGNS AND SYMPTOMS.

No apology need be offered for dealing rather fully with the signs and symptoms that would lead one to suppose an injury had been done to the bladder. The remarks which follow will make it clear that these lesions may escape notice in the early stage when a comparatively simple operation may save life. Wounds in the buttock region especially must be regarded with the utmost suspicion until their direction and extent have been carefully studied. An intraperitoneal wound of the bladder or other pelvic viscus may be entirely overlooked, as in *Cases* 2, 20 (18a), 27 (25a), 31 (29a), and 47 (16b).

In *Case* 2 the patient gave a history of something falling across the abdomen when a shell struck his dug-out. There was a wound of the right leg and one of the scrotum. When admitted to a base hospital next day he had slight rigidity of the lower abdomen, did not complain of any pain, but was tender over the hypogastrium. A catheter drew off 30 ounces of urine, containing some albumin, a few pus cells, but no blood. Death took place four days after receipt of the wound. Post mortem, peritonitis was found, due to an intraperitoneal rupture of the bladder (*Fig.* 14). In this case the symptoms were very indefinite, and the recovery of 30 ounces of clear urine by catheter deceived the medical officer.

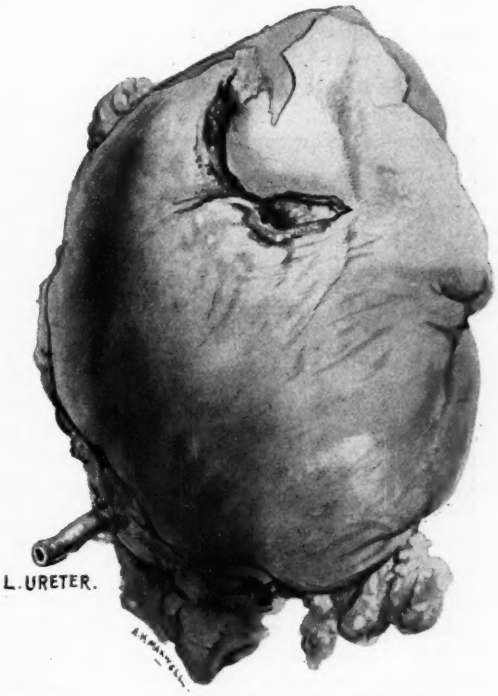


FIG. 14.—Intraperitoneal rupture of bladder (*Case* 2). The peritoneal covering is split to a greater extent than the remaining coats of the bladder. Note the exudate due to peritonitis.

In *Case* 20 (18a) there was a wound in the left buttock. A catheter drew off 5 ounces of clear urine. The note from the clearing station stated that there was no vomiting, no true rigidity, and no dullness in the flanks. Death took place at a base hospital two days after injury. The post-mortem revealed four perforations in the small intestine, and a wound of the bladder communicating at the bottom of the pouch of Douglas with the peritoneal cavity; general peritonitis was present.

In *Case* 27 (25a) a piece of shell, entering by the right groin, had gone through the bladder and torn a hole in the rectum through its peritoneal surface. Laparotomy was performed at the base two days later, but the patient succumbed from peritonitis.

In *Case* 47 (16b) a shrapnel ball had entered by the right buttock and lodged in the bladder. The patient was evacuated to the base next day. On his arrival at hospital Colonel Elder diagnosed commencing peritonitis, and performed laparotomy. There was blood-stained, urinous-smelling fluid in the peritoneal cavity. The site of the leak was not clear, but peritonitis was already well established. The patient made a good recovery after removal of the fluid in the peritoneal cavity and suprapubic cystostomy.

The fact that these cases escaped diagnosis in the early stages shows that symptoms of bladder involvement are by no means always definite and unequivocal.

Shock.—Shock is likely to be present when other severe injuries, such as extensive fractures of the pelvic bones or wounds of intestine, complicate the case. According to Wallace,[3] it is one of the chief causes of death at the clearing stations. It is important to remember, however, that shock may be almost entirely absent in certain wounds which prove later to have penetrated to the bladder or even to one of the other hollow viscera in the pelvic region.

Hæmorrhage.—Hæmorrhage, like shock, contributes largely to the high mortality of wounds of the bladder at the front. Cases with a history of severe hæmorrhage do not often reach the base. In the early stages severe bleeding may take place into the peritoneal cavity or from the external wound. Wallace[3] states that wounds of the pelvic veins are responsible for a great deal of the hæmorrhage. In addition to the bleeding which takes place externally and into the abdominal cavity, a considerable amount of blood is often found in the bladder. The urine voided or removed by catheter usually contains blood in greater or lesser quantity, but two of the cases just cited show that this important sign may be absent. In the cases arriving at the base the quantity varied from a slight colouring of the urine to large clots which distended the bladder. In some instances a considerable amount of ecchymosis in the skin and extravasation of blood in underlying tissues was present. This was apparent in several cases in the hypogastrium, the perineum, or the scrotum and penis.

Leakage of Urine.—Leakage of urine from the wound in the bladder is one of the most important accompaniments of injury to the organ. This may appear at the wound in the parietes, or be more or less concealed in the form of extravasation into cellular tissue or leakage into the peritoneal cavity. In cases reaching the base, a urinary fistula was most frequent in the region of the buttock. When the rectum was also injured, a rectovesical fistula usually resulted (*Fig.* 15), and urine either escaped into the bowel, or was discharged, often accompanied by fæces, from a wound in the parietes. The urine may escape from the entrance wound, from the exit wound when present, or from a wound made by the surgeon for drainage or the recovery of a foreign body. In some cases the appearance of the fistula may be delayed for a few days after the occurrence of the injury. In *Case* 36 (5b), for instance, urine did not make its appearance in the wound until three days had elapsed. This was, no doubt, due to the time taken for the disintegration and discharge of sloughs in the long fistulous track. Although it is quite common for urine to escape into the rectum, it has not been noticed in the cases under review that there has been much tendency for the fæces to be discharged into the bladder. The escape of gas by the urethra, however, has been noted, as in *Case* 32 (1b). The size of the communicating opening between the bladder and rectum will, of course, determine the occurrence of this disagreeable complication.

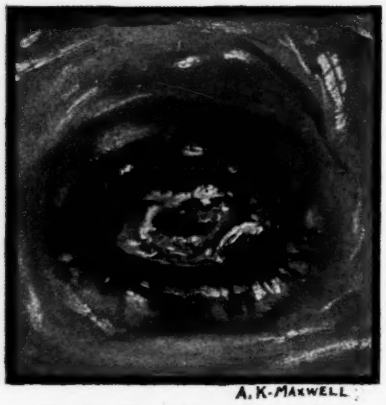


FIG. 15.—Sigmoidoscopic view, nine days after injury, of anterior wall of rectum, showing recto-vesical fistula, 2½ inches from anus, produced by a bullet which passed transversely between bladder and rectum. Note the central slough and the surrounding inflamed area. Recovery without operation.

In most of the cases of the present series there was a urinary fistula, and, as has been stated, the site was most frequently the buttock. Other situations were the suprapubic region, the ischiorectal fossa, the groin, and the thigh. In a few cases there was no fistula. In *Case* 25 (23a), for instance, though a foreign body $1 \times 1 \times \frac{1}{2}$ cm. in size was found in the bladder, no leakage took place through the parietes. In *Case* 28 (26a) (*Fig.* 21), where two minute foreign bodies were seen in the bladder, there was no leak at any time. In *Case* 15 (13a), it is perhaps doubtful if the missile had actually perforated the bladder; no leakage was observed.

Urine which has escaped from the bladder may fail to reach the surface and be extravasated into the perivesical tissue described in the paragraph on anatomy. Under these circumstances it may show itself as a diffuse swelling in the suprapubic region, or may be detected as a tumefaction in the pelvis by rectal examination.

Retention of Urine.—After an injury to the bladder it is quite common for the patient to be unable to micturate for two or three days. If the wound is small, distention of the bladder may occur and require the use of the catheter. This applies, of course, to those cases in which suprapubic cystostomy has not been performed.

Pain.—A sudden, sharp pain may occur when the bladder is struck. When the patient arrives at the base, however, pain referred to the bladder is not a constant feature. If a foreign body has been retained in the bladder, or if cystitis has supervened, the recognized symptoms of these conditions will be present.

Tenderness and Rigidity.—In a fair proportion of cases of bladder injury, even if entirely extraperitoneal, there is some tenderness and rigidity in the hypogastrium. The presence of these signs led to an incorrect diagnosis of intraperitoneal injury and to exploratory laparotomy in 5 cases. Nevertheless, with the cases previously mentioned in our mind, in which a timely laparotomy might have saved life, we are bound to admit that it is better to err on the safe side, lest an intraperitoneal perforation should escape attention.

Vomiting.—Vomiting is occasionally seen in cases of bladder injury in which the peritoneal coat is intact. On the other hand, it may be entirely absent in the first hours of an intraperitoneal lesion.

Fever.—As in most war wounds, fever is commonly present, and depends largely upon the amount of infection in the soft parts and bone. When it persists, pelvic cellulitis, abscess formation, osteomyelitis, or spread of infection to the kidney, should be suspected.

METHODS OF EXAMINATION.

In examining a case of suspected injury to the bladder, attention should be paid to the position and direction of the wounds, and to the accurate localization of foreign bodies, if present. Radiography will determine the presence or absence of bone lesions and the situation of retained projectiles; cystoscopy will discover a missile or bone fragment in the cavity of the bladder, or a lesion of its wall; and rectal examination will give valuable information as regards wounds of the lower bowel, fluid accumulations in the pelvic connective tissue, and palpable foreign bodies. Leakage of urine into the peritoneal cavity may fail to give rise at first to acute abdominal symptoms, so that a careful watch must be kept on all doubtful cases. Fluid issuing from a wound in the parietes may be diagnosed as urine by its smell, by chemical examination, or by its becoming rapidly coloured after subcutaneous or intramuscular injection of such substances as indigocarmine or methylene blue. The amount of urine escaping may be very small, most of the contents of the bladder being expelled by the natural passage, or the greater part of the urine may leak through the wound in the parietes. The quantity will vary with the size of the opening in the bladder, the length and calibre of the fistula, and the amount of swelling present in its walls. In a few cases of bladder injury leakage occurs only during efforts to micturate, or is increased thereby. As a rule, however, it is continuous and independent of micturition. In cases of injury to the urethra, on the contrary, leakage occurs only during micturition, unless the sphincteric apparatus of the bladder is also damaged. Fluid injected at the meatus readily escapes from the fistula, as a rule, in urethral injuries, whereas in bladder injuries this is not likely to take place until considerable pressure has been used and a larger amount of fluid has been injected. The distinction is of importance from the point of view of treatment. The integrity of the sphincter vesicæ is valuable in protecting the bladder from infection, especially if the urethral wound is made to communicate freely with the surface by an incision in the perineum. I have had the opportunity of examining several of these cases, and have found the bladder healthy, except when it has been infected by a catheter. Suprapubic cystostomy under these circumstances is unnecessary and harmful.

The position of the ureter as it skirts the pelvic wall should be kept in mind. A leak from the buttock may be due to an injury of this structure (*Fig.* 6). Cystoscopic examination with ureteral catheterization would prove invaluable in such a case.

Hæmaturia should raise strong suspicions of bladder injury, but it is necessary to emphasize the fact that cases of hæmorrhagic cystitis have been comparatively frequent during this war, and that this condition may be present in a wounded man apart from bladder injury. The following case illustrates difficulties that may be encountered. A man was struck with a large piece of shell in the loin at the level of the iliac crest. Forty-

FIG. 17.—Contusion of bladder wall produced by shrapnel ball. Ecchymosis, with large adherent clot. From *Case* 1, two days after injury.

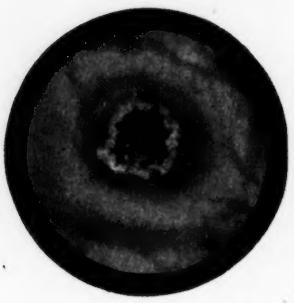


FIG. 18.—Wound of bladder wall behind trigone, produced by shell. Localized cystitis. From *Case* 6 (4a), six days after injury.

FIG. 16.—Hæmorrhagic cystitis following a wound in the lumbar region. No direct injury to kidney, ureter, or bladder.

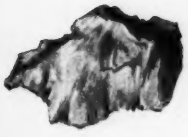
FIG. 19.—Wound of entrance and bullet in bladder. Moderate degree of cystitis W = Wound; U = Ureteric orifice. From *Case* 13 (11a), 13 days after injury.

FIG. 21.—Two small fragments of shell in bladder. Patches of ecchymosis on mucous membrane. From *Case* 28 (26a), 3 weeks after injury.

FIG. 20.—Shell fragment in bladder. Slight degree of cystitis. From *Case* 24 (22a), four days after injury.

FIG. 22.—Scar on posterior wall of bladder after a wound by shrapnel ball. Mild degree of cystitis, and a few flecks of muco-pus. From *Case* 52 (21b), two months after injury.

CLOTH.



MISSILE.

FIG. 23.—Large piece of shell ulcerating through bladder wall. Note the adherent sloughs and the surrounding cystitis. From *Case* 53 (22b), thirteen days after injury.

eight hours later he had severe hæmaturia. On cystoscopic examination, we found intense congestion of the bladder wall, obliteration of the vessels, numerous patches of ecchymosis widely scattered, and films of muco-pus attached to the mucous membrane. Streptococci and staphylococci were found in the urine. When the cystitis had subsided, ureteral catheterization was carried out. The specimen from each ureter contained streptococci, albumin, some leucocytes, and a few red cells. Casts were also present. I was at first inclined to the view that we were dealing with a case of 'concussion' of the bladder from shell injury, but further experience would suggest that this was a case of hæmorrhagic cystitis, the infecting organism having probably gained entrance to the circulation by the wound. *Fig.* 16 represents the condition found when the cystitis had largely disappeared, leaving the patches of ecchymosis still unabsorbed. If there was any doubt in a similar case in future, the sigmoidoscope might be used to ascertain if any similar patches were present in the rectum. Patches in both bladder and rectum would favour the diagnosis of trauma.

Finally, if the surgeon is still in doubt, a measured quantity of bland fluid may be injected into the bladder, and the amount recovered ascertained. This is a clumsy method, and may fail to give the desired information. If a cystoscope is at hand, and the skill to use it available, a small aperture that might otherwise be missed may be discovered. As there is likely to be a good deal of ecchymosis in the neighbourhood of the wound, the surgeon may thus be guided to a perforation.

Cystoscopy.—Routine cystoscopic examination in bladder injury is not possible in war time. Nevertheless, I have been able to carry out this procedure in 11 cases, representing several types of injury. I have not had the opportunity of conducting examinations within the first few hours; the earliest period has been two days after injury. The following cases were investigated in this way:—

Case 1, in which a shrapnel ball had contused but not penetrated the bladder, was examined two days after injury. A hæmatoma of the bladder wall with an adherent clot was found. There was no cystitis (*Fig.* 17).

Case 3 (1a), in which a wound of the bladder, rectum, and sacrum had been produced by a bullet, was examined about a month after injury. A disappearing cystitis of moderate degree was found.

Case 6 (4a), in which a fragment of shell had produced a wound of the bladder, giving rise to leakage in the buttock, was examined six days after injury. Localized cystitis of moderate degree was found, and, behind the trigone, a circular aperture about a third of an inch in diameter and dark in colour. The last was probably an entrance wound, covered with sloughs, but it may have been commencing necrosis of the mucous membrane over the situation of a piece of metal known to be retained in the pelvis (*Fig.* 18). On the left lateral wall, a spot covered by a white membrane was seen. This was probably the site of an exit wound produced by a second piece of metal, also known to be retained further forward in the pelvis. An area of œdema and redness in the vicinity of the white membrane, and spots of ecchymosis posterior to the latter, were also seen. On the right side of the bladder, the vessels, though blurred, were visible. Flecks of muco-pus were seen scattered over the mucous membrane.

Case 9 (7a), in which a piece of shell had wounded the bladder and rectum and embedded itself in the sacrum, was examined eight days after injury. Cystitis was present, but no ecchymosis was seen. The aperture in the bladder could not be detected.

Case 13 (11a), in which a bullet had entered the bladder after producing six perforations in the small intestine, was examined thirteen days after injury. The bullet was seen lying free in the cavity (*Fig.* 19). There was a mild degree of cystitis, and some ecchymosis on the anterior wall, against which the bullet had impinged before falling back into the bladder. The wound of entry, previously dealt with by laparotomy, was represented by a slit in the mucous membrane of the posterior wall. Its slit-like appearance may have been due to the previous suture of the peritoneal surface by Captain Thomas at a clearing station. There was some redness and œdema around the wound. The lips of the slit were curled a little outwards.

Case 14 (12a), in which a shrapnel ball had wounded the bladder and led to leakage through the buttock, was examined ten days after injury. A small area, of deep-red velvety colour, with flecks of muco-pus on it, was found far back on the posterior wall, a little to the right of the middle line, surrounded by healthy mucous membrane. There was a good deal of redness around the left ureteral orifice. The aperture in the bladder wall could not be identified.

Case 22 (20a), in which a bullet had traversed the neck of the bladder or the prostate, shattering the pubic bone, was examined six months after injury. There was a moderate degree of cystitis, most marked at the base, and phosphatic débris on the way to become a calculus. Specimens

were obtained from both ureters, and were found to be free from albumin, pus, and blood. The aperture, being so far forward, was invisible by the cystoscope.

Case 24 (22a), in which a piece of shell had entered the bladder after having lacerated the rectum and prostate, was examined four days after injury. There was a mild degree of cystitis, and the foreign body could be seen lying free, surrounded by blood-clot. After washing away the latter a coloured drawing was made (*Fig.* 20). The urethroscope was now used to ascertain the position of the opening, which was found in the prostatic urethra, partially hidden by greyish, cauliflower-shaped granulations.

Case 28 (26a), in which two minute fragments of shell had entered the bladder, was examined three weeks after injury. There was a mild degree of cystitis, the vessels being blurred, but still visible. Two minute angular particles were found free on the bladder wall. Several small points of ecchymosis were seen on the right side, one or two just outside and above the ureteral orifice, and three or four on the right lateral wall (*Fig.* 21).

Case 52 (21b), in which a shrapnel ball had injured the coccyx, the rectum, and the bladder, was examined two months after injury. There was a slight degree of cystitis, and a radiating scar was seen on the posterior wall, with a leash of vessels converging towards it. The appearance is well seen in *Fig.* 22. A raw surface marked the position of the suprapubic wound, not yet completely healed.

Case 53 (22b), in which a fragment of shell had lodged in or near the bladder wall, was examined thirteen days after injury. Well behind the interureteric bar, near the middle line, an aperture was seen about one-third of an inch or so in diameter, with white adherent sloughs. The edges of this opening were red and swollen and rather sharply cut. There was much œdema and cystitis around. At the base of the bladder the vessels were blurred but still visible. After clearing away some of the sloughs with a stiff ureteral catheter, the foreign body was disclosed lying in a cavity communicating with the interior of the bladder. The coloured drawing represents accurately the state of affairs found (*Fig.* 23).

It will be noticed that in some of these cases the aperture in the bladder was not discovered. This is particularly likely to occur when the opening is near the neck, an area almost impossible to examine with the ordinary cystoscope. In the other cases the aperture may have been hidden by hæmorrhage or inflammatory swelling.

The presence of patches of ecchymosis appears to be a common feature, and this is what one would expect.

The degree of cystitis was very much less than might have been anticipated, especially with shell wounds, in several of which portions of clothing were known to have been carried in. In some the cystitis was local in character, and in all it was of a moderate degree of severity. Attention will be drawn later to two cases, not cystoscoped, in which a more virulent cystitis was present, and in which necrosis of the mucous membrane resulted; on the whole, however, the condition of the mucous membrane of the bladder was a secondary feature in the case. This comparative immunity may have been due to the careful irrigation carried out in most of the cases; but one is driven to the conclusion that the mucous membrane in a healthy young subject is resistant to infection.

It is impossible to state the characteristic appearances of an opening produced by a missile from the cystoscopic findings here recorded. Large tears and perforations preclude the possibility of cystoscopy, and these descriptions must be regarded as examples of certain types of injury only.

COMPLICATIONS.

Pelvic Cellulitis is the most important complication of wounds of the extraperitoneal area of the bladder. There were 5 cases in the present series in which it was the cause of, or greatly contributed to, the fatal issue. The anatomical conditions which favour its occurrence and the direction of its spread have been already described.

Peritonitis.—Peritonitis is likely to occur when there has been an intraperitoneal injury to the bladder alone or in association with one of the other pelvic viscera. In the 4 cases in which it occurred it was due to an unrecognized lesion of small intestine, rectum, or bladder, and death ensued in 3 of these. In the remaining case, early recognition, followed by operation, saved the patient.

Extravasation of Urine.—As has been incidentally mentioned, a certain amount of extravasation of urine is likely to take place in extraperitoneal wounds. The infiltration takes place in the perivesical and perirectal connective tissue, but is not common between

the bladder and rectum at the area where these structures are closely connected by firm fibrous adhesions. In several cases it was an important factor. It produced sloughing of the scrotum in *Case* 43 (12b); in *Case* 48 (17b) the bladder was found on operation to be floated up as on a water-bed on a collection of urine which had extravasated from a lesion of the anterior wall; in *Case* 51 (20b), in which the prostatic urethra was found completely severed from the bladder, a large space was found at the base of the latter, filled with old blood-clot, urine, and fæculent material.

Cystitis. — It is probable that in every case of penetration of the bladder a certain amount of cystitis, local or general, occurs. In the cases examined with the cystoscope, the degree of cystitis was comparatively slight and the symptoms mild. In the present series the patients treated otherwise than by suprapubic cystostomy did not suffer from the scalding, tenesmus, frequency of micturition, and penile pain so common in severe cystitis in civil practice. The cystoscopic appearances in the few cases examined have already been described. In the following two cases the condition was sufficiently severe to cause necrosis of a considerable area of the mucous membrane. In *Case* 12b (43), treated by suprapubic cystostomy for a bullet wound of the lateral wall, a cast of the bladder came away later, on washing through the suprapubic wound. In *Case* 28a (30), already referred to, the patient died from pelvic cellulitis and gas gangrene of the ilio-psoas and muscles of the adductor region, following a bullet wound which traversed bone, rectum, and bladder. On post-mortem examination the mucous membrane over the greater part of the bladder was found grey and necrotic (see *Fig.* 12). Microscopical examination confirmed the diagnosis. The micro-organisms found in the urine, in the cases bacteriologically examined, included streptococci, staphylococci, and coliform bacilli.

Epididymitis.—This is liable to occur, first, when the prostatic urethra is involved, as in *Case* 11 (9a), and secondly, when the vesiculæ seminales or ejaculatory ducts have shared in the injury. In *Case* 17 (15a), in which the rectum was also involved, it is quite likely that the epididymitis spread back from the vesicula or the ejaculatory duct of that side. In *Case* 28 (26a) also it was thought that this was the cause of a severe epididymitis. There were, in all, 3 cases with this complication while the patients were in France.

Spread of Infection to the Kidneys.—As a rule the cases in the present series were not kept sufficiently long in France to allow time for the development of this complication. Whether it is a common occurrence or not will be shown by the future history of the cases, when that is available. *Case* 22 (20*a*) was examined from this point of view six months after an injury to the neck of the bladder. The sinuses in the buttock and thigh had not entirely closed at this date, as a large amount of bone had had to be removed for necrosis. The kidneys were quite free from disease, though cystitis had been present, probably for a considerable time. In *Case* 34 (3b) the post-mortem report states that there was some passive congestion of the kidneys and some pus in the pelves. In *Case* 35 (4b) suppression of urine occurred before death, but the post-mortem report states that there was no apparent kidney trouble. In several other post-mortem reports it is stated that the kidneys were healthy.

Osteomyelitis and Necrosis.—Cases with osseous fracture are frequently complicated by osteomyelitis and necrosis. In *Case* 22 (20a), for instance, a large portion of the right side of the pubic bone necrosed and was removed. Necrosed fragments were also removed in *Case* 11 (9a). Doubtless a number of the cases evacuated to England will require sequestrotomy.

Involvement of the Hip-joint.—This occurred in *Case* 22 (20a), and was due to the extension of a rarefying osteitis from the seat of fracture to the acetabulum. No suppuration took place in the joint, and the latter finally settled down with some restriction of movement. In *Case* 30 (28a) the hip-joint was involved, but the patient died before any symptoms referable to it became manifest.

Gas Infection.—There were 4 cases of severe gas infection, involving the abdominal wall in *Case* 8 (6a), the groin in *Case* 10 (8a), the adductor region in *Case* 30 (28a), and the glutei and psoas muscles in *Case* 44 (13b). In the last two cases it was a contributory

cause of death. In one of the fatal cases, 30 (28a), the mucous membrane of the bladder was necrotic, but it is difficult to say whether this was due to anaerobic infection or not.

Secondary Hæmorrhage.—In *Case* 9 (7a) very severe hæmorrhage took place on the twelfth day, shortly after an attempt to remove a foreign body embedded in the sacrum. In the other cases no hæmorrhage sufficient to call for special treatment occurred while the patients were in France.

Fæcal Fistula.—Fæcal fistula was present in 15 cases. In 14 of these it communicated with the rectum. In the remaining case, 8 (6a), the fæces appeared to come from the small intestine, twenty inches of which had been removed by a previous laparotomy. In this case fæces appeared in the abdominal wound on the ninth day after operation, accompanied by a discharge of urine. In many of the above cases the wound in the parietes discharged both urine and fæces. The position of the rectal wound or wounds can in some cases be found by digital examination, or, if this fails, by the sigmoidoscope.

Rectovesical Fistula.—Among the 19 cases of injury to the rectum, a rectovesical fistula was present in 13.

Fæcal Extravasation.—A small amount of pent-up fæcal extravasation in the perivesical space was found in *Case* 51 (20b).

Lung Complications.—Bronchitis of a severe type was present in *Case* 22 (20a), and pneumonia, probably septic, in *Cases* 34 (3b), 41 (10b), and 51 (20b). The latter was a very serious complication, and all three cases died.

Intestinal Obstruction.—In *Case* 45 (14b) adhesions took place between the small intestine and the spot at which an intraperitoneal injury to the rectum had been sutured. The patient died.

MORTALITY AND CAUSES OF DEATH.*

Wallace[3] gives the mortality of *uncomplicated* bladder wounds as 56 per cent, 14 deaths in 25 cases; he says, "in the cases of complicated wounds, the picture is dismal in the extreme." In the present series the mortality was over 24 per cent, 13 deaths in 53 cases reaching the base. The cause of death in these cases was as follows:—

Case 2.—Died from peritonitis due to an intraperitoneal rupture of the bladder caused by a fall of earth on the abdomen. Laparotomy was not performed. (See *Fig.* 14.)

Case 20 (18a).—Shell wound. Died from peritonitis following four perforations in the small intestine. There was, in addition, an extraperitoneal wound of the bladder and a fracture of the ischium. Laparotomy was not performed.

Case 27 (25a).—Shell wound. Died from peritonitis following an intraperitoneal injury to bladder and rectum. There was also a fracture of the pubic bone. A late laparotomy was performed at the base.

Case 30 (28a).—Bullet wound. Died of pelvic cellulitis and gas gangrene of the ilio-psoas, pectineus, sartorius, gracilis, and adductors, following an extraperitoneal wound of the bladder complicated by fracture of the pubic bone and head of femur and a wound of the rectum.

Case 32 (1b).—Shrapnel-ball wound. Died from pelvic cellulitis following an extraperitoneal wound of the bladder complicated by fracture of the symphysis and a wound of the rectum.

Case 34 (3b).—Shell wound. Died from pelvic cellulitis and septic pneumonia following an extraperitoneal wound of the bladder complicated by fracture of the iliac bone and the ischium. There was, in addition, a compound fracture of the bones of the right forearm and a wound of the left leg.

Case 35 (4b).—Bullet wound. Died of pelvic cellulitis extending downwards and backwards from the space of Retzius, following an extraperitoneal wound of the bladder complicated by a large rent in the rectum.

Case 37 (6b).—Nature of missile unknown. Died of pelvic cellulitis following an extraperitoneal wound of the bladder. There were no complicating injuries.

Case 9 (7a).—Shell wound. Died from hæmorrhage in the depths of the pelvis after an attempt to remove a foreign body. There was also an extraperitoneal wound of the outer coats of the rectum not involving the lumen.

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* See corrections under 'Late Results,' p. 45.

Case 41 (10b).—Nature of missile unknown. Died of septic pneumonia following an extraperitoneal wound of the bladder complicated by an extensive fracture of the pubic bone. The anterior wall of the bladder had been torn away.

Case 51 (20b).—Bullet wound. Died of septic pneumonia following an extraperitoneal wound of the bladder complicated by injury to the prostate and rectum and fracture of the pubic bone and great trochanter of the femur.

Case 45 (14b).—Shell wound. Died of intestinal obstruction after suture of an intraperitoneal wound of the rectum.

Case 44 (13b).—Bullet wound. Died of gas gangrene of the glutei and psoas muscles with generalized anaerobic infection, following an extraperitoneal wound of the bladder complicated by fracture of the bones of the obturator foramen.

Of the gunshot wounds that proved fatal, 5 cases had, as complications, injury to the rectum and the bones of the pelvis, 3 had bone injury, 2 had injury to the rectum, 1 had injury to small intestine and bone, and 1 had no bone or bowel complication.

One of the most frequent causes of death was pelvic cellulitis. Of the 5 cases in which death was due to this cause, 4 were treated by early suprapubic cystostomy, and 1, *Case* 30 (28a), by drainage of the bladder through existing wounds.

TREATMENT.

In a previous communication,[4] I expressed views on the treatment of certain types of wounds of the bladder, which did not meet with universal acceptance. These views I still hold. In the present article the evidence upon which they are based will be given as fully as possible.

The indications for treatment in cases of injury of the bladder in warfare appear to me to be as follows :—

1. All foreign bodies, including missiles, fragments of bone, pieces of clothing, and blood-clot, should be removed from the bladder as soon as possible. This may be done by way of the original wound, by washing out through the urethra, or by cystotomy. If cystotomy is performed, the opening in the bladder may be closed by suture in suitable cases.
2. The wound in the bladder, if accessible, whether it be intraperitoneal or extraperitoneal, should be closed if possible.
3. After operation, care must be taken to keep the interior of the bladder clean by frequent and thorough irrigation until the urine is clear.
4. Careful attention should be paid to the perivesical and perirectal cellular tissue, to prevent, if possible, extravasation, accumulation, and the spread of pelvic cellulitis.
5. The wound in the parietes should be dealt with as thoroughly as the anatomical peculiarities of the affected region permit.

In the remarks which follow, it will be seen how far it has been possible to carry out treatment on these lines.

Intraperitoneal Wounds are usually treated by laparotomy at the clearing stations. A few which have not been operated on reach the base. The rent in the bladder should be treated by inversion of the edges and a continuous Lembert suture of catgut, reinforced, if necessary, by a second layer. The mucous membrane should be excluded, so as to avoid, if possible, the exposure of much suture material in the cavity of the bladder, where it may form a nucleus for the deposit of phosphatic concretions. In a few cases it has not been possible to get at the perforation so as to secure accurate apposition and a water-tight repair. In *Case* 40 (9b), for instance, Captain Hamilton Drummond found it impossible to deal with a perforation situated low down in the pouch of Douglas by the intra-abdominal route. He opened the bladder, therefore, and closed the perforation from within by a purse-string suture of catgut, reinforced by two additional sutures of the same material. A length of damaged small gut was resected at the same operation. The bladder was drained suprapubically. The case did well while in France.

In *Case* 52 (21b), again, in which there was an intraperitoneal perforation of both bladder

and rectum situated low down in the pelvis, Captain Sampson found it impossible to suture the apertures, and resorted to the expedient of shutting off the openings from the general peritoneal cavity by a line of sutures across the pelvic floor. A suprapubic cystostomy was performed, and an iliac colostomy. The patient was doing well when I saw him two months later.

In *Cases* 7 (5a) and 21 (19a), both of which were operated on by Captain D. C. Taylor at a clearing station, it was possible to close completely the intraperitoneal opening. In both cases there was also damage to small intestine, necessitating resection. Suprapubic cystostomy was not carried out, and a catheter was not tied in. Both made a satisfactory recovery, and were able almost immediately to pass urine in the natural way.

It would appear, therefore, that the ideal way to deal with these intraperitoneal injuries is to suture the perforation accurately, and refrain from suprapubic cystostomy and the tying-in of a catheter. If the union is not deemed to be watertight, as in the first two cases, suprapubic cystostomy, to prevent leakage into the peritoneal cavity, is the correct treatment. The management of cases with an extraperitoneal wound in addition is sufficiently indicated by what follows.

Extraperitoneal Wounds.—If there is a single extraperitoneal wound in an accessible position, and it is possible to suture the margins—after excision of the damaged edges, if necessary—it is good practice to do so. An exit should be provided in the parietes for escape of urine in the event of leakage taking place. This procedure is only possible in such situations as the suprapubic region, where the bladder approaches the surface of the body. If there are two extraperitoneal wounds, it is unlikely that both will be accessible. As a rule it is only the most dependent of these that leaks, and the surgeon will be guided by his experience and judgement, and by a consideration of some of the cases about to be cited, as to what course he is to pursue.

In *Case* 5 (3a) the entrance wound was close to the external abdominal ring. Captain H. F. Vellacott excised the edges of the rent in the bladder, and closed it with catgut sutures. Dirt and khaki were removed from the space of Retzius. The missile, a shrapnel ball, was retained between the bladder and rectum. Although leakage took place from the sutured bladder, the case did well.

In *Case* 12 (10a) a missile had passed from the buttock to the suprapubic region, fracturing the symphysis pubis. An extraperitoneal rent in the bladder, suprapubic in position, 1½ in. long, was sutured with fine catgut by Captain Shaw. Although blood and urine leaked from the wound in the buttock, the patient began to pass water twenty-four hours after operation, and was evacuated to England doing well.

In *Case* 16 (14a) an injury to the lateral wall of the bladder was sutured, and a small drain was placed in the neighbouring perivesical space. There was also a wound of the rectum, communicating with one in the buttock. A large drainage tube was passed through the buttock wound to the opening in the rectum. Lieutenant-Colonel Upjohn, who, later, had the patient under care at a base hospital, reports that the patient arrived in excellent condition. There was never any leakage of urine, and he was evacuated to England passing urine and fæces naturally. Extraperitoneal wounds situated in the neighbourhood of the base and sides of the bladder, and difficult of access, have given us a good deal of trouble and anxiety. These must be left, as a rule, to drain through the wounds in the parietes.

The two following cases illustrate a method of dealing with a cystotomy wound made to remove a foreign body in the bladder. In *Case* 13 (11a) Captain Thomas had closed an intraperitoneal wound in the bladder, and six perforations of the ileum. When the patient arrived at the base, a cystoscopic examination disclosed the presence of a bullet free in the bladder. The position of the bullet was located with the cystoscope, a pair of long dressing-forceps was pushed through the bladder wall by the suprapubic route, and the missile removed. The bladder was not further opened, and very little subsequent leakage took place (see *Fig.* 19). In *Case* 24 (22a) a piece of shell had entered the bladder by way of the buttock and rectum. Cystoscopic examination showed its presence and position in the bladder (see *Fig.* 20). Here, again, an incision in the suprapubic region was made down to the bladder wall, and a pair of forceps was pushed through to grasp and remove the missile.

The small opening in the bladder was sutured in this case, and no leakage took place at this spot, though urine still filtered to the surface through the rectal wound. The patient was sent home within a fortnight, and a letter was received from him a few days later to say that all his wounds were healed and that he was getting about.

In the subsequent management of cases such as those that have been described, one of the secrets of success is the attention given to the cleansing of the interior of the bladder. The method which has proved most satisfactory in my experience is the following: The bladder is thoroughly irrigated with plain boiled water until all shreds, mucus, and pus have been washed away. As soon as the water returns clear, a solution of nitrate of silver is used, beginning with 2 grains to the pint, and gradually increasing day by day to 8 or 10 grains. This procedure is repeated, at first daily, and then every two days, till the urine is clear. Under this treatment cystitis very rarely makes headway, and the patient is kept perfectly comfortable as regards his urinary organs. Some of the fluid escapes by the urinary fistula, if this is present, and washes it from within out.

The importance of the perivesical tissues can hardly be overestimated. In extraperitoneal wounds, if free exit is not provided, there is nothing to prevent the urine from extravasating round the base and sides of the bladder, to the posterior part of the rectum behind and the space of Retzius in front. The diagnosis of accumulation of urine and septic matter and of the onset of pelvic cellulitis will be made by pelvic examination and by attention to the pulse and temperature and the general condition of the patient. Treatment must be conducted on sound lines. Suprapubic cystostomy, even if performed early, does not seem sufficient. Of the 5 cases that died of pelvic cellulitis, 4 were treated by early suprapubic cystostomy. The following case, 51 (20b), will serve to illustrate the inadequacy of drainage through the bladder. A bullet had injured the prostate gland and neck of the bladder. Suprapubic cystostomy had been carried out at a clearing station. On arrival at the base the case was seen by Captain Bush, who recognized that the drainage was insufficient. Dissecting down on the bladder from the perineum, he struck a large space filled with old blood-clot, urine, and some fæcal matter.

Whenever it is desired to reach accumulations of fluid or collections of pus in the neighbourhood of the prostate and neck of the bladder, or to provide for drainage in this region, a transverse incision in the perineum between the anus and the bulb of the urethra, gradually and carefully deepened, gives the best access. The anal canal is drawn backwards and the bulb forward until the prostate is reached.*

Farther up, the rectum is so closely adherent to the bladder that collections are not likely to occur between them in this region, and it is not necessary to separate these structures. The part requiring drainage will be that lateral to the vesiculæ seminales, the side depending on the position of the wound in the bladder and the situation of accumulations if present. To reach this area, the following dissection may be done. Make an incision in the ischiorectal fossa parallel to and just medial to the ischiopubic ramus on the side affected. Pass the finger upwards medial to the obturator internus, and define the supero-medial boundary of the ischiorectal fossa—the levator ani muscle. The perivesical space can be entered by tearing through this muscle and its enclosing fascia. In making this dissection the surgeon will probably incise the base of the triangular ligament, but the artery to the bulb will be avoided by keeping posterior to a line drawn transversely from the bulb to the pubic ramus. In *Fig.* 24—a coronal section through the distended bladder and the prostate in a man age 40—the perivesical space is shown exaggerated in extent, and it will be seen how an incision through the levator ani will reach it at the point most suitable for dependent drainage. This section has been prepared for me by Mr. P. T. Crymble, and drawn by Miss Rea, to illustrate the perivesical space and the method of approach here recommended. In *Case* 11 (9a), I was able to deal somewhat in this fashion with an abscess cavity into which urine was being discharged from an injury near the neck of the bladder. Suprapubic cystostomy was

* To illustrate this method, a recent case of Captain D. C. Taylor's, not included in the present series, is briefly described at the end of ' Particulars of Cases ' (see p. 56).

not performed, as it was judged more satisfactory to deal with the case in the way indicated. The patient, who had necrosis of the pubic bone in addition, made a good recovery, and was evacuated to England with all wounds healed except a small fistula in the perineum. In *Case* 46 (15b) a somewhat similar procedure was carried out. The bladder was floated up by a collection of urine which had extravasated from wounds in the lower part of its anterior wall. A space surrounding the side of the bladder next the entrance wound in the buttock was thus easily reached and drained. The patient made a rapid and satisfactory recovery, and was evacuated to England, passing urine naturally and with all wounds healed, about three weeks after operation.

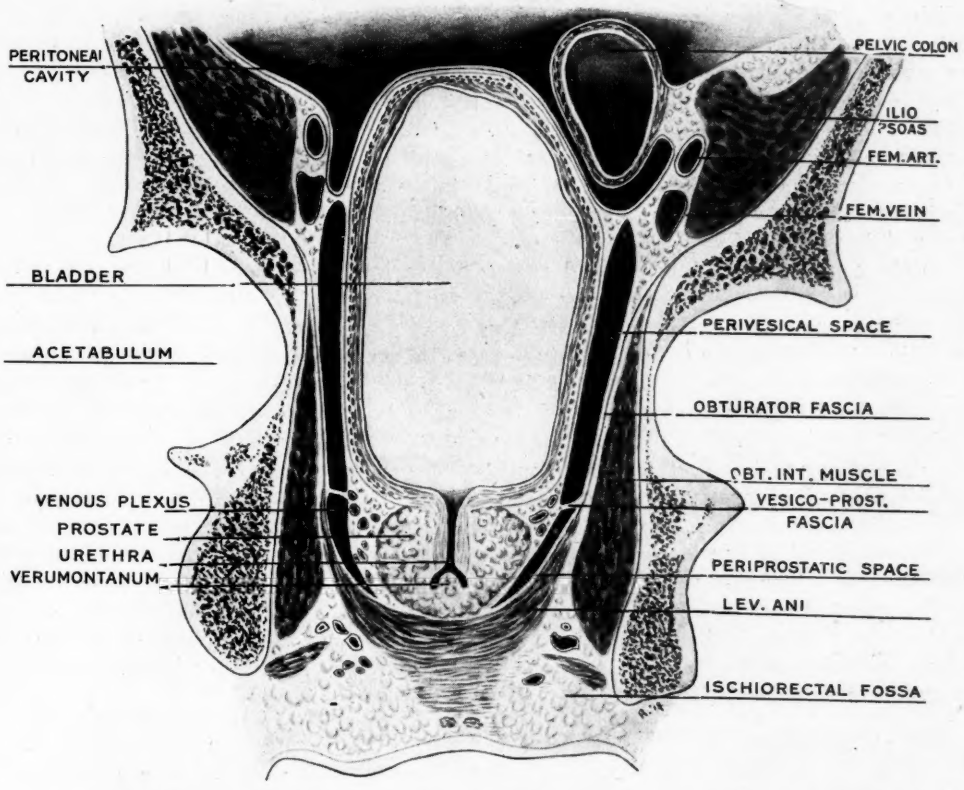

FIG. 24.—Coronal section through the distended bladder and the prostate of a man aged 40. The perivesical space is shown exaggerated in extent.

Treatment of the Wound in the Parietes.—As has been stated, the gravity of bladder injuries depends to a large extent upon the concomitant injury to the soft parts, the other pelvic viscera—particularly the rectum—and the bone. The wound is often so situated that excision of the track is impracticable for anatomical reasons. The best that can be done under these circumstances is to provide drainage, as free as possible, right down to the aperture in the bladder. Tubes, if used, should not enter the cavity of the latter. If the aperture is near the base, leakage, more or less, will probably occur whatever system of bladder drainage be employed. Free exit for urine must therefore be provided. If accumulation in the perivesical tissues and the depths of the wound can be prevented, the flow of healthy urine over the surfaces, even if bone or rectum be involved, will not be harmful. If, on the other hand, it is impossible by free drainage through the wound to prevent extravasation, a more suitable exit must be found by a dissection which leads directly to the injured area or the space in which the accumulation lies. I have indicated the lines upon

which such a dissection should proceed in the area most likely to be affected, viz., the base and lateral aspects of the bladder. Suprapubic cystostomy is insufficient to effect this drainage. If the bladder be not further mutilated by cystostomy, it will tend to contract upon its contents and drive them out through the wound, cleansing the latter in the process. The wound discharges are thus driven from within outwards by the force of the bladder contractions, and if the onset of cystitis can be prevented by careful lavage, the healthy aseptic urine will act as a continuous irrigator from the depths of the wound to the surface. If, on the other hand, the positive pressure in the bladder is removed by cystostomy, the organ collapses, and stagnation tends to occur in the tissues outside its walls. It is more likely that fluid accumulation will pass back into the bladder and infect it, if the *vis a tergo* which forces it to the surface has been lost, than under the reverse conditions. I am aware that these opinions run contrary to those of surgeons of great repute. Both Legueu[2] and Makins[5] mention cases of wounded bladder in which patients were not doing well, who improved after suprapubic cystostomy, but neither of these authorities mentions what attention was given to the bladder to prevent infection of that cavity. I can well understand that the urine from a badly-infected bladder would be injurious to a wound in the parietes, not to speak of the risk of upward spread to the kidneys; under these circumstances, cystostomy would be indicated. If, however, cystitis can be prevented, or efficiently controlled, I prefer, for the reasons stated, to avoid opening the bladder.

In the cases appended at the end of this paper, and those quoted in the text, I have marked all those treated without suprapubic cystostomy with the letter '*a*,' and those treated by suprapubic cystostomy with the letter '*b*.' There were, in all, 51 cases of perforation of the bladder (in one of these penetration was perhaps doubtful). Of these, 29 were treated without opening the bladder for drainage; 4 died, two of peritonitis from intraperitoneal lesions which had escaped notice at the clearing stations, one of hæmorrhage, and one of pelvic cellulitis and gas gangrene. The remaining 22 were treated by suprapubic cystostomy; 8 of these died, four of pelvic cellulitis (one of which had pneumonia in addition), two of pneumonia, probably septic in origin, one of intestinal obstruction, and one of gas gangrene. The two sets of cases were of the same degree of severity, and were almost identical as regards the percentage of associated injuries to bone, rectum, and small intestine. The late results are not known in all the cases, and it may be that cystostomy has been necessary later in the cases not so treated in France, for bladder or renal infection, for foreign bodies which have escaped notice, or for calculus formation. At the base, however, and I only speak of the cases that have come under my own notice, the best results have been obtained by the treatment I have outlined.

The Treatment of Associated Injury to Other Pelvic Organs.—Intraperitoneal injuries of the small intestine, rectum, or pelvic colon will be dealt with by laparotomy in the usual way. Extraperitoneal wounds of the rectum should be sutured, if possible; in most cases, however, this will be unsuccessful, and a fæcal fistula will follow. Many of these fistulæ do well without colostomy, but occasionally the wound in the parietes becomes so foul that an operation to divert the flow is necessary. This is specially indicated: (1) If there is a large communication between the bladder and rectum; (2) If an intraperitoneal wound of the rectum cannot be accurately sutured, as in *Case* 21b; (3) If fæces are discharged between the fragments of a compound fracture. If colostomy is necessary, the opening should always be made in the transverse colon, for reasons which I have mentioned in a previous paper,[4] viz.:

1. The stoma is far removed from the wounded area and from a cystostomy opening if present.
2. The opening is easily controlled.
3. Restoration of continuity is easily accomplished.
4. Should it become necessary later to remove part of a damaged rectum, the pelvic colon may be mobilized and brought down to supply the deficiency if it has not previously been interfered with by an iliac colostomy.

To these may be added :

5. The risk of a ventral hernia is less after a transverse colostomy than after one in the iliac region.

In the present series, colostomy was performed in 6 cases. In 3 the opening was made in the transverse colon, with 2 deaths ; and in 3 an iliac colostomy was performed, with 1 death. The result in the fatal cases was quite unconnected with the operation.

The treatment of rectovesical fistulæ which fail to close spontaneously is carried out at the home hospitals, and need not be described here.

LATE RESULTS.

The publication of this paper has been delayed in order to await replies to a number of inquiries made in England as to the after-histories of the cases upon which it is based. These enquiries have been sent through the Medical Research Committee by Colonel T. R. Elliott, their representative in France, to whom I am much indebted for the trouble he has taken. The subsequent history of 21 cases has been ascertained, and I have thought it well to correct and complete as far as possible the account given in the preceding pages.

Additional Deaths.—Three additional deaths have to be recorded, bringing the mortality rate from 24 to 30 per cent. *Case* 8 (6a) died five weeks after injury, from what appears to have been intestinal obstruction. He had had about 20 inches of his small intestine resected in France. No post-mortem was made. *Case* 19 (17a) died in England eighteen days after receipt of his wound, but no further particulars are available. *Case* 22 (20a) died suddenly while straining to relieve his bowels, a little over six months after being wounded. His wounds were almost healed, and his urinary organs were functioning well at the time of his death. Post mortem, dilatation of the heart, with fatty degeneration of its walls, was found. The patient had passed through a long period of fever and suppuration during the early part of his illness, but had been apparently quite well for several weeks before his death.

Remaining in Hospital.—There were still 6 cases in hospital at periods varying from three to nine months after injury.

Unfit for Further Military Service.—There were 7 cases 'discharged unfit' at periods varying from five months to a year and five months after injury.

Back to Duty.—Only 4 cases are known to have returned to duty—*Case* 4 (2a) at the end of ten months, *Case* 23 (21a) at the end of five months, *Case* 39 (8b) at the end of nine months, and *Case* 47 (16b) at the end of four months after injury.

Complications and Sequelæ.—The following complications and sequelæ were noted in the replies received :—

Bone Injury.—In two cases bone injury was discovered in England which had been overlooked in France—in *Case* 19 (17a) fracture of the "pelvis," and in *Case* 29 (27a) fracture of the pubic bone. This raises the number of cases complicated by fracture from 42 to 45 per cent.

Vesical Calculi.—Vesical calculi were found in 4 cases. One of these, *Case* 18 (16a), had been treated in France without suprapubic cystostomy, and three, *Cases* 36 (5b), 38 (7b), and 46 (15b), had had suprapubic cystostomy performed at clearing stations. The calculi were discovered six months, ten months, and five months respectively after injury in *Cases* 16a, 5b, and 15b. In *Case* 7b the date is not mentioned.

Stricture.—In *Cases* 22 (20a) and 38 (7b), late reports state that dilators were required for commencing stricture. This sequela is likely to occur when the lesion is in the region of the prostate and neck of the bladder.

Secondary Hæmorrhage took place thirteen days after injury in *Case* 18 (16a). The patient recovered.

Sequestrotomy was necessary in *Case* 26 (24a) four months after injury.

Sciatic Pain on the same side as a buttock wound is recorded in the notes of *Case* 4 (2a).

Abscess in Testicle.—An abscess was found involving the testis and epididymis in

Case 36 (5b). Gonococci were obtained from the urethra, but there is no note of the organisms present in the abscess.

Epididymitis was recorded in the notes of *Case* 46 (15b). This probably spread from a cystitis which was present.

Cystitis and Pyuria.—Very few cases up to the time of writing were quite free from pus in the urine, and moderately severe cystitis was noted as being present in several. Some of these had been treated in France by cystostomy, and some without.

With these reports to hand the fate of nearly all the cases is known. Several were quite well on leaving France, and letters from a few others stated that they were convalescent. In *Cases* 17 and 50 a good deal of leakage of urine from the wounds was present on transference to England, and no reports have been received concerning their later progress.

Comment.—While these notes of after-results are very incomplete, they demonstrate certain facts of some importance.

1. Injuries of the bladder are of very severe import both as regards the life and the subsequent health of the patient.
2. The persistence of pyuria demonstrates the necessity for continuing bladder irrigation long after the wounds have been healed. When we have been able to keep the patients under observation and to carry out systematic irrigation, the results as regards cystitis and pyuria have been much better. Urinary antiseptics ought to be given in addition.
3. The development of calculi, as in *Case* 46 (15b), for instance, in which I cleared out all blood-clot and débris at the primary operation, is probably due to the subsequent separation of sloughs and the persistence of a certain amount of cystitis. Here, again, I feel sure that the continuance of frequent irrigation of the bladder would tend to minimize this risk.

Taken as a whole, the later results of injuries of the bladder are disappointing in the extreme, and suggest that constant, prolonged, and skilled after-treatment, in special hospitals if possible, is necessary if we are to look for any definite improvement.

CONCLUSIONS.

1. Injuries of the bladder form a very small proportion of the total wounds reaching the base hospitals.

2. Their importance from the point of view of prognosis and treatment depends to a large extent upon associated injuries.

3. The more usual associated injuries are those of the bones of the pelvic girdle and of other pelvic viscera. The most frequent viscus found injured in cases reaching the base is the rectum. Injuries of the pelvic colon and small intestine are comparatively rare in cases seen at the base.

4. The importance of the perivesical connective tissue cannot be overestimated. This forms a potential, continuous space extending from the cavum Retzii in front, round the sides of the bladder and rectum, to the posterior part of the latter behind. Pelvic cellulitis is a frequent complication.

5. The mortality of bladder injuries is very high. In cases reaching the base it may be estimated at 30 per cent. The chief causes of death have been pelvic cellulitis, peritonitis, and sepsis.

6. The chief sequelæ, judged from the reports reaching us from England up to the present, are necrosis of bone, persistence of cystitis, calculus, and stricture at the neck of the bladder. Sufficient data are not at present available to enable us to judge of the frequency of extension of infection to the kidney. J. Tanton[6] mentions that in a series of 137 cases of wounds of the bladder collected by him, 10 cases of pyelonephritis occurred, in 3 of which calculi formed requiring nephrolithotomy.

7. The treatment should be conducted on common-sense lines. Accumulations of infected fluid, blood-clot, and fæcal material in the pelvic connective tissue must if possible be prevented by attention to the original wounds. If this is unsuccessful, suitably

planned incisions should be made. The fact that urine flows over the surface of a wound is not necessarily in itself an indication for suprapubic cystostomy. If the bladder can be kept clean by irrigation, aseptic urine from the kidneys does not appear to have a deleterious effect on the wound.

8. Suprapubic cystostomy will drain an infected bladder, but will not prevent pelvic cellulitis and sepsis from occurring in the perivesical connective tissue and parietes respectively. The after-treatment of the bladder by frequent irrigation is necessary to get rid of cystitis and prevent calculus formation.

I desire to express my thanks to the officers who have assisted me with the notes of these cases; to the Medical Research Committee for the services of their artist, Sergeant A. K. Maxwell; to the latter for his keen interest and his careful delineation of the cystoscopic appearances; to Mr. P. T. Crymble, for permission to use *Figs* 6 to 9; and to Mr. P. T. Crymble and Miss Rea for *Fig.* 24.

PARTICULARS OF CASES.

In the descriptions of cases which are here appended it has been necessary to be as brief as possible. Only the main points in each case are mentioned, and the reports from England are abbreviated to give such information only as is likely to be of service to the medical officers who have had to do with the cases in France.

Case 1.—Capt. W., under care of Major Martin. Wounded by shrapnel ball Aug. 25, 1916. Entrance right gluteal fold. Fracture ascending ramus of pubis, right side. Admitted to base hospital, Aug. 27. Operation same day; cystoscopy showed hæmorrhage on bladder wall with attached floating clot (*Fig.* 17); foreign body together with some loose fragments of bone removed through suprapubic incision; shrapnel ball partially embedded in wall of bladder on right antero-lateral surface about 1½ ins. behind pubis. Urine leaked from suprapubic wound second day after operation; probably bladder was injured by bone fragments. Bladder irrigated with silver nitrate daily. Evacuated to England doing well, Sept. 9, 1916.

Case 2.—Pte. J. W., under care of Major McEwen. Wounded Aug. 12, 1917; penetrating wound of leg and laceration of scrotum. Gave a history of something falling across abdomen when shell struck dug-out. Admitted base hospital, Aug. 13. Bowels had not moved since accident, nor had patient passed urine. Catheter drew off 30 oz. of urine showing some albumin and a few pus cells, but no blood. General condition very poor; slight rigidity of lower abdomen. Bowels moved by enemata and pituitrin given every four hours. Aug. 14, began to vomit and hiccough: did not complain of pain; was tender over lower part of abdomen. Aug. 15, pulse weak and rapid, patient very listless; abdomen did not present any definite signs of peritonitis; slight dullness in flanks. Seen by consulting surgeon, who did not consider him fit for any operation. Death early next morning.

Post-mortem.—Intraperitoneal rupture of bladder (a longitudinal slit about 1¼ in. in length), and peritonitis (see *Fig.* 14).

Case 3 (1a).—Pte. A. F. S., under care of Captain Kelly. Bullet wound, Aug. 2, 1915. Entrance 1 in. above pubis and 1 in. to right of middle line; exit through third piece of sacrum to right of middle line. Bladder full at time of injury. Admitted base hospital, Aug. 8. A slight leakage from anterior wound; bulk of urine passing by large exit wound. Hæmorrhage. Rectum injured. Aug. 9, transverse colostomy. Irrigation of posterior wound with eusol. Wounds cleaned rapidly. Micturition normal early in September (about a month after injury). Cystoscopy showed cystitis of moderate degree. Discharged to England Sept. 21.

Report from England, March 2, 1916.—"Patient practically cured. Colostomy closed, and no discharge from remains of sinuses. About to leave for a convalescent home."

Case 4 (2a).—Sergt. A. L. Shell wound Oct. 3, 1915. Felt slight pain at time of injury. Later tried to pass water, and felt sharp, hot pain in region of wound; unable to pass water; no vomiting. Catheter drew off 8 oz. of blood-stained urine. Entrance wound in suprapubic region; exit left buttock. Catheter had been tied in at C.C.S. Cystoscoped Oct. 10: on anterior wall of bladder, aperture, plugged by muco-pus; orifice irregularly circular with œdematous edges; blood oozing from this orifice; patches of blood extravasation in neighbourhood extending as far as left lateral wall; cystitis; on left lateral wall an area indicating exit wound which is somewhat indistinct. (This cystoscopic examination was inadvertently omitted when describing cystoscopy in text.) Leakage same day from suprapubic entrance wound. Oct. 31, wounds dry.

Report from England states that three months after injury there were still traces of pus in the urine. Left sciatic pain was complained of. Wound of left buttock was healed on Jan. 2, 1916, and patient returned to duty Aug. 5.

Case 5 (3a).—Lieut. A., under care of Captain H. F. Vellacott. Wounded with shrapnel ball, about March 24, 1916. Entrance close to left external ring; no exit. Urine flowing from wound. Operation; laparotomy; peritoneum found to be only slightly wounded; reflected upwards; rent in bladder excised and stitched with catgut; dirt and khaki removed from cave of Retzius; drain to bladder stitches; laparotomy wound closed. Bladder wound began to leak, April 1; otherwise doing well. Stereoscopic radiography shows bullet near 3rd and 4th sacral vertebræ. Ball can be felt per rectum. Evacuated to England, doing well.

Case 6 (4a).—Rfm. H., under care of Major West. Shell wound, May 26, 1916. Entrance wound right buttock; no exit. No bone injury. No leakage of urine until May 30, when urine began to trickle through buttock wound independent of micturition. Temperature a little raised, 99°; general condition good. Radiography showed two pieces of shell in pelvis. Patient has urgency, but is unable to pass water. Urine foul-smelling and containing pus. June 1, cystoscopy: cystitis (appearances have been described in text). June 4, urine almost clear; bladder has been washed out with nitrate of silver solution. Track of missile: skin, gluteus maximus, great sacro-sciatic foramen, obturator internus and levator ani muscles, and vesiculæ seminales. June 13, evacuated to England, apparently quite well.

Report from England.—Wound healed July 1, about five weeks after injury. Feb. 2, 1917, discharged unfit for further service.

Case 7 (5a).—Pte. McK., under care of Captain D. C. Taylor, and subsequently of Major West. Shell wound, June 5, 1916. Entrance left side mid-axillary line, 1½ inches above iliac crest; no exit. At C.C.S., vomiting, pulse 140; blood in urine withdrawn by catheter. Scalp wound. Laparotomy by Captain Taylor; pelvis full of blood and urine; small intestine perforated in 11 places, with 2 tears in mesentery; four feet resected, end-to-end anastomosis; small hole in posterior wall of bladder just admitting finger; piece of shell in bladder removed and bladder sutured; abdomen closed, pelvic drain. Catheter passed every four hours. June 6, passing urine normally. June 14, wound in abdominal wall healed, except for track of drainage tube; patient quite well.

Case 8 (6a).—Pte. H. E., under care of Captain J. H. Thomas. Shell wound June 30, 1916. Entrance front of abdomen; considerable portion of abdominal wall blown away. Extensive gas infection. July 1, 20 inches of small intestine resected, end-to-end anastomosis; abdominal muscles partly pulled together with through-and-through sutures of silkworm gut; these cut out later, and the floor of the abdominal wound was formed by bowel. On ninth day, a fæcal fistula developed at upper end of wound. No hæmaturia, and he has passed perfectly clear urine without difficulty since his injury. Since operation, free escape of urine from depths of wound. Captain Thomas could see no perforation of bladder at time of operation; shell fragment had hit right side of symphysis and then passed into the thigh internal to vessels; fragment not removed. When seen at the base on July 18, huge wound in right iliac region, with urine flowing from lower part. All urine comes through wound; general condition good; some fæces coming through upper part of wound.

Report from England.—Aug. 1, bowels open, some urine leaking. Aug. 2, has been very ill, vomiting, no distention, pulse bad, wounds looking well, temperature 103°. Aug. 4, bowels will not act in spite of enemata, etc.; no marked distention, but incessant vomiting; died same day.

Case 9 (7a).—Pte. J. S., under care of Captain Bazett. Shell wound, July 2, 1916. Entrance right buttock; no exit. Said to have passed some blood per anum. Urine coming from two wounds in buttock. Large piece of shell in right side near sacro-iliac joint. July 10, cystoscopy; appearances have been described in text. Per rectum, some thinning of outer wall of bowel on right side and posteriorly along course of track. Urine contains much pus, coliform organisms, and staphylococci. July 13, small piece of shell removed from the smaller wound; larger piece embedded in sacrum; an attempt to remove this failed. Secondary hæmorrhage same day; direct transfusion of blood. Died July 17, from hæmorrhage.

Case 10 (8a).—Pte. J. F., under care of Captain Edye. Shell wound, July 9, 1916. Entrance wound right buttock near anus; passes into rectum and across latter to involve prostate. Shell fragment removed by Captain Edye, July 11, from left groin, where gas infection had developed. There were also two wounds in left buttock. Urine comes from rectum on micturition; none by the normal passage. There is a large hole in the prostate. Missile had gone through right side of rectum near anus, through anterior wall of rectum, and then out into left groin, where it was found just under skin; track lies internal to the femoral vessels. Radiography subsequently showed fragment of shell in the middle line behind pubis, and on a level with its upper border. Operation, July 12; fragment removed with a long pair of forceps through the wound in prostate and rectum. July 24, temperature normal; patient quite well; urine still coming per anum; passes some by normal passage. July 31, most of the urine coming per urethram.

Case 11 (9a).—Rfm. F. L., under care of Captain McDonnell. Shell wound, July 9, 1916. Entrance wound left buttock; missile tunnelled across rectum just inside anus, passing through

right side of rectum to the suprapubic region. Urine was coming from wound made at the C.C.S. in right groin, and from wound in buttock. July 14, radiography showed fracture of horizontal and descending rami of pubis at junction with body. July 27, condition good; wounds clean; urine from wound in buttock, fæces also through buttock; passed some urine per urethram. Aug. 25, temperature has been up for two days, 102° and 103°; urine coming from wound in right groin. Explored; necrosis of pubic bone; fragments removed; urethra found almost entirely divided at junction with bladder. Catheter comes out through wound in groin. Much pus. A small sinus in posterior wall of rectum leading to lumen just above external sphincter. Captain McDonnell reports pus in large quantities in urine; this evidently came from wound, and passed into urethra, as bladder when washed out was easily rendered clean. Aug. 26, operation; ischiorectal fossa explored; wound found to be in right side of prostate; large wound in groin, passing inside the pelvic wall to ischiorectal region; an incision which involved the right side of the triangular ligament at its base was made to counter-drain. Sept. 10, patient very well, passing water through perineal wound at will; wound in groin almost healed. Sept. 29, all wounds healed except that in perineum. Oct. 28, epididymo-orchitis on left side, settling down. Nov. 7, most of urine coming naturally.

Report from England.—March 16, 1917, discharged unfit for further service, about seven months after injury.

Case 12 (10a).—Lieut. M., under care of Captain Shaw. Wounded, Aug. 12, 1916. Entrance wound left buttock; large exit above symphysis, blood and urine flowing therefrom. Operation, Aug. 13; large extraperitoneal tear of bladder 1½ inches long; large fragments of symphysis detached, and others still adhering to periosteum; all pieces likely to cause damage removed; bladder stitched in two layers, catheter tied in, and suction drainage established for twenty-four hours; catheter then passed in the ordinary way every four hours for the next twenty-four hours. Blood soon disappeared from urine, and on following three days patient passed urine normally. Aug. 20, transferred to the base. Aug. 23, letter received from him stating he was doing well.

Case 13 (11a).—Pte. A. P., under care of Captain J. H. Thomas. Bullet wound, Sept. 1, 1916. Entrance wound right buttock; no exit. On admission to C.C.S., pulse 106; no vomiting; abdomen very rigid, no movement, no distention, painful and tender. Small amount of blood in catheter specimen. Laparotomy early next morning; large quantity of blood and clot in peritoneal cavity; no obvious urine; bullet had entered abdomen internal to right iliac vessels; laceration of mesentery of small intestine; 6 small perforations of ileum, all of them closed by suture; bullet had penetrated bladder at a point about half way up its superior surface; bullet could not be felt; perforation closed with a double row of catgut sutures; abdomen closed; prevesical space explored, and another small hole in anterior wall of bladder discovered; this was also closed with a double row of catgut sutures; it was thought that bullet had embedded itself in the symphysis; space of Retzius drained. Passed urine naturally without difficulty since operation; some hæmaturia for two days. Patient complained both before and after operation of the stream of urine being suddenly stopped, with a sharp spasmodic pain running down the penis. Radiography shows the bullet lying below the symphysis. Cystoscopic appearances have already been described in text; see also *Fig.* 19. Sept. 14, operation; bullet located by cystoscopy, and removed by forceps pushed through anterior wall of bladder. Very little leakage took place from this small wound. Evacuated to England, Sept. 16, doing well.

Case 14 (12a).—Pte. A. E., under care of Major West. Wounded by shrapnel ball, Sept. 15, 1916. Entrance wound right buttock. Bladder full at time of injury. Twenty-four hours later passed urine, and noticed blood in it, and that fluid came through the wound in the buttock at the same time. Missile retained. Urine only comes through buttock when he passes water. Pain in perineum just after micturition, lasting for fifteen minutes. Sept. 18, quantity of urine coming from buttock wound diminishing. Radiography shows shrapnel ball lying behind the ascending ramus of pubis at juncture with ischium. Urine contains much blood and pus. Sept. 21, no visible blood; temperature, which had been raised, is now normal. Cystoscopic appearances have already been described in text. Sept. 27, evacuated to England; normal temperature; normal micturition, and no evidence of cystitis.

Case 15 (13a).—Pte. T. F., under care of Captain Kelly. Shell wounds, Nov. 18, 1916. Many wounds of buttocks and thighs; peppered all over. Noticed blood in his urine a day or two later. Nov. 24, blood present in urine; no frequency of micturition; some suprapubic pain; burning pain on micturition. Radiography shows a piece of metal just in front of coccyx, to right of middle line, and another very small piece in the abdominal cavity to left of middle line, 3½ inches above level of symphysis pubis, about 1½ inches in front of second segment of sacrum; this has apparently gone through the bladder from below up; several pieces scattered about right hip-joint, and several present in buttock. Nov. 26, blood, albumin, and pus still present in urine. Dec. 3, running a temperature up to 103°. Dec. 11, evacuated to England, with blood still present in urine.

Report from England.—Aug. 17, 1917, discharged from hospital no longer fit for war service, nine months after injury.

Case 16 (14a).—Lieutenant-Colonel Upjohn's case. Wounded left buttock, nature of missile not stated. Injury to rectum and lateral extraperitoneal bladder wall. Laparotomy; bladder

sutured; small drain to perivesical wounded tissues. Never any escape of urine. Rectum drained by a large tube in buttock wound. Patient arrived at the base in excellent condition, passing urine and fæces naturally. Evacuated to England the following day. Nothing further is known of this case.

Case 17 (15a).—Sgt. F. C., under care of Captain Bush. Wounded, probably by a bullet, April 9, 1917. Two days after injury, explored through buttock wound, which was very foul, and communicated with rectum and bladder. Urine leaking through rectum and wound in buttock. Retained at base hospital for fourteen days. Left-sided epididymitis. Evacuated to England, not yet passing urine naturally.

Case 18 (16a).—Pte. R. W. W., under care of Lieutenant-Colonel Upjohn. Bullet wound, April 9, 1917. Entrance left buttock or thigh, to suprapubic region. Urine escaping freely from 2 slit-like groin wounds. Wound in buttock opened up; iliac bone found perforated; wound in right groin opened up. Eighteen days after operation, passing urine almost entirely per urethram.

Report from England.—April 22, secondary hæmorrhage from buttock. Oct. 13, calculi passed per urethram. Nov. 27, some small calculi have come away recently. Dec. 6, seen by Mr. Thomson Walker, who suggested constant irrigation of bladder. Dec. 11, condition greatly improved; taken off constant irrigation. Jan. 18, 1918, still in hospital, nine months after injury.

Case 19 (17a).—Pte. W. E. W., under care of Captain Reford. Wounded, April 9, 1917, nature of missile not stated. Entrance right buttock, traversed pelvis, and emerged in front of great trochanter of opposite side. No operation. Hæmaturia. April 14, urine emerging from exit wound, none from buttock or perineum.

Report from England.—Fractured pelvis. Ruptured bladder. Died, April 27, 1917. No further details available.

Case 20 (18a).—Pte. E., under care of Captain Hemmans. Shell wound, April 9, 1917. Field medical card lost, no notes from clearing station. Admitted base hospital April 11. Temperature 97·4°, pulse 132. Patient very ill; restless; abdomen tender in lower part, no true rigidity; no dullness in flanks. Catheter drew off 5 oz. clear, highly-coloured urine. Per rectum, nil. Wound of left buttock at level of great trochanter; finger in wound detected fracture of the ischium, and disclosed a cavity containing a large quantity of offensive, blood-stained fluid with urinous odour. Patient never rallied, died same day.

Post-mortem.—Diffuse peritonitis, especially in pelvis; four perforations in lower ileum; recent adhesions; large piece of shell about size of an almond lying within peritoneal cavity. Large hole in base of bladder. Compound comminuted fracture of spine of ischium. Wound in bladder was extraperitoneal. Missile had passed on, after wounding bladder, through rectovesical pouch to left side.

Case 21 (19a).—Rfm. O., under care of Captain D. C. Taylor, and subsequently of Major McEwen. Bullet wound, May 22, 1917. Entrance right iliac region; exit in perineum 1 in. in front of anus. At C.C.S., vomiting; hard, rigid abdomen. Laparotomy, six hours after injury, by Captain Taylor; free blood and urine in peritoneal cavity; small bowel cut across; another large tear sutured; 8 inches of ileum resected, and end-to-end anastomosis; a tear, 1½ inches, in right side of bladder sutured with double layer of sutures; abdomen closed without drainage. Patient has passed urine naturally since operation. May 29, has made good recovery; has no symptoms other than a little distention; not necessary to pass catheter; laparotomy wound healed by first intention. Seen at base, May 30, patient quite well; temperature and pulse normal; bowels acting well; passing urine normally. June 11, patient quite well.

Case 22 (20a).—Pte. W. L. H., under care of Captain Swan. Bullet wound, June 27, 1917. Entrance right buttock, outside and a little posterior to anus; exit same side, inner side of femoral vessels. June 28, escape of urine by buttock wound. Pubic rami shattered; prostate injured, Has passed some blood per urethram. Urine leaks during micturition. Blood, pus, coliform bacilli, and streptococci in urine. Had bronchitis and was very ill with high temperature for weeks. Large loss of bone. Bladder washed out daily. July 23, pieces of necrosed bone removed. Lotion injected per urethram comes out of wound. Aug. 4, pain and rigidity in hip of affected side. Aug. 20, passed some urine per urethram. Radiography shows rarefying osteitis of acetabulum and head of femur. Still running an evening temperature of 101° to 102°; it comes down for a few days and then goes up again. Hip fixed in splint. Sept. 24, passed about 20 oz. of urine naturally. Oct. 11, still some urine from wounds. Oct. 27, abscess in left groin, which had tracked from opposite side, opened. Nov. 8, temperature now settled; passing urine normally; no frequency; urine almost clear. Dec. 3, cystoscopy—appearances have already been described in text; some difficulty in introducing instrument owing to commencing stricture in prostatic urethra. Dec. 31, apparently no leak. Jan. 3, 1918, died suddenly from cardiac failure, a little more than six months after injury.

Post-Mortem.—Cardiac degeneration.

Case 23 (21a).—Dvr. W. W., under care of Captain Dawes. Shell wounds, July 2, 1917. Entrance left buttock, large wound. Foreign body removed. All urine by buttock wound. Other wounds on buttocks. July 8, fæcal-smelling discharge coming from buttock wound, probably due to a large slough, which was removed by Captain Dawes. Running a moderate temperature

up to 101° in the evenings. July 23, some urine per urethram. July 31, passed per wound large slough with very offensive smell, apparently from bladder. Aug. 6, most of urine per urethram. Aug. 22, wound dry. Sept. 16, urine clear; pain in the area of distribution of external popliteal nerve. Wound quite healed; marked for evacuation.

Report from England.—Oct. 31, radiography shows no evidence of calculus. Nov. 15, doing well; no trouble with micturition, urine quite normal. Nov. 24, fit for discharge: furlough and command depôt.

Case 24 (22a).—Pte. G. M., under care of Major Smith and Captain Lindsay. Shell wound, July 7, 1917. Entrance wound right buttock; missile entered rectum and passed through apex of prostate. Some urine escapes by rectum on micturition. Passed blood after being hit. Blood and pus in urine. Radiography shows foreign body 4½ inches from anterior surface of body, about level of lower end of coccyx; sectional anatomy shows it to be at level of posterior wall of bladder. July 9, cystoscopy; foreign body in bladder (*Fig.* 20); cystoscopic appearances already described in text. Running a moderate temperature of 100° to 101° in the evenings. July 11, operation; missile removed by pushing forceps through anterior wall of bladder; opening so made sutured; abdominal wall sutured except at lower end. July 18, passing nearly all urine by wound at anus; temperature going down. July 24, all urine per urethram.

Report from England.—Aug. 18, still some pus in urine. Oct. 9, urine is clear. Dec. 20, discharged permanently unfit, five months after injury.

Case 25 (23a).—Pte. J., under care of Major Maunsell. Shell wounds, July 31, 1917; scalp, thigh, and buttock on right side. Says he passed port-wine-coloured urine after being hit. When admitted to C.C.S. a catheter was passed, but no gross blood in urine; radiography at C.C.S. showed foreign body in pelvis. Arrived at base hospital, Aug. 3. Retention of urine; catheter passed; no blood; bladder sound passed; some resistance at internal meatus; no foreign body felt; bimanually nothing discovered; cystoscope passed; inner tube removed to wash out bladder; could not be replaced; attempt made to withdraw cystoscope to ascertain reason; point of instrument caught in urethra, and could not be removed; the foreign body had been caught between telescope and outer tube of cystoscope proximal to the lamp. The foreign body could be felt on under surface of urethra in front of the scrotum; cut down upon and removed; wound in urethra sutured. Foreign body measured 1 × 1 × ½ cm. It had evidently lodged in bladder, and caught in the cystoscope during manipulation. Good recovery.

Case 26 (24a).—Pte. J. D., under care of Major Harper. Shell wound, Aug. 8, 1917. Entrance over sacrum. Notes from C.C.S.: Gunshot wound of sacrum; metal removed from bladder; bladder sutured; drain tube to space of Retzius. Had passed urine naturally since operation. Admitted to base hospital, Aug. 9; posterior wound leaking urine; anterior wound almost healed. Aug. 12, fæcal-smelling discharge from posterior wound; some leakage from anterior wound. Reconstruction of track: sacrum, rectum, vesiculæ seminales, pelvic connective tissue, bladder. Aug. 23, leaking from suprapubic wound. Sept. 1, no leakage from either wound. Sept. 11, wounds almost healed.

Report from England.—Dec. 4, small sequestrum removed from sacral region. Jan. 5, 1918, urine cloudy, alkaline, contains pus and albumin; sinus at back of sacrum opened up and curetted. Jan. 7, urine oozing through sacral wound. Jan. 28, still in hospital, five months after injury.

Case 27 (25a).—Pte. W. H., under care of Major Everidge while at base. Shell wound, Oct. 12, 1917. Entrance right groin; no exit; track went superficial to femoral vessels, wounding vein, passed through horizontal ramus of pubis on right side into bladder extraperitoneally, then out through peritoneal aspect of bladder across rectum, tearing the gut, to lodge finally in wall of pelvis on opposite side. Admitted to base hospital Oct. 13; vomiting; rising pulse; abdomen tender in lower half, somewhat rigid, distended. About 1 oz. of urine containing blood had been drawn off at C.C.S. On arrival at base, urine was leaking through wound in groin, which was foul and gassy. Oct. 14, laparotomy; longitudinal rent about 1 in. long on peritoneal aspect of bladder sutured with two layers of catgut; transverse slit in rectum reaching to the lumen also sutured; foreign body lying in a hole in lateral wall of pelvis not removed, patient being too ill for further manipulation. Death thirty-six hours later from peritonitis.

Case 28 (26a).—Pte. W. R., under care of Major Harper. Shell wounds, Sept. 26, 1917. Peppered all over buttocks. At field ambulance, two hours after injury, vomiting, rigidity of lower half of abdomen, and tenderness, particularly on left side; hæmaturia; catheter tied in. At C.C.S., catheter removed; patient improving rapidly and passing urine naturally. Sept. 28, admitted to base hospital. Still some hæmaturia. Knee-jerks absent, band of hyperæsthesia corresponding to 11 and 12 D. Urine dribbling at times, and fæcal incontinence. Oct. 5, incontinence has passed off; wounds nearly healed; urine alkaline and contains pus and blood. Oct. 9, right epididymitis. Oct. 10, tenderness over bladder, and pain at point of penis after micturition; temperature 103°. Oct. 16, temperature falling; cystoscopy—already described in text (*Fig.* 21); two minute foreign bodies seen in bladder.

Report from England.—Nov. 4, good control of urine, but some frequency. Nov. 13, no discomfort in passing urine. Nov. 20, radiography shows no foreign body in or near bladder (they had probably been passed per urethram). Report on urine, Nov. 7: albumin nil, small number of pus cells.

Case 29 (27a).—Pte. L., under care of Major D. Crawford. Wounded Oct. 7, 1917, and lay out four days. Entrance wound just above pubis immediately to left of mid-line; exit right buttock at level of ischial spine. Oct. 13, admitted to base hospital. Urine and fæces leaking through buttock wound. Track in buttock passes into rectum. Per rectum, large hole in anterior wall at apex of prostate communicating with bladder, admitting index finger. Bladder drained through rectum by rubber tube; buttock wound also drained by tube. Suprapubic wound had entirely healed. Highest temperature 101°, highest pulse-rate 108. Marked for England Oct. 20.

Report from England.—Nov. 2, operation; some fragments of fractured right pubic bone removed. Nov. 19, a little urine per urethram. Jan. 28, 1918, still in hospital, three months after injury.

Case 30 (28a).—Pte. McF., under care of Captain Hemmans. Bullet wound, Oct. 12, 1917. Entrance wound left buttock; exit, larger in size, just below right anterior superior iliac spine. Admitted to base hospital Oct. 15. Temperature 98·6°, pulse 112; general condition poor; exit wound very septic; blood-stained urine per rectum and per urethram. Oct. 18, rigor, temperature 105·6°. Nov. 19, died.

Post-mortem.—Track from left buttock through great sacro-sciatic foramen, perforating rectum twice, bladder twice extraperitoneally, fracturing horizontal ramus of pubis and head of femur of opposite side. Pelvic cellulitis in front and to right side of bladder. Gas gangrene of iliopsoas, pectineus, sartorius, gracilis, and adductors. Acute cystitis, with necrosis of mucous membrane of bladder; this necrosis was in the form of a number of raised patches, firm, greyish in colour, and was situated chiefly on base and posterior wall. Kidneys normal.

Case 31 (29a).—Pte. W., under care of Lieutenant-Colonel Hurley. Wounded, Sept. 26, 1917, by jumping into a shell hole and impaling himself on bayonet of comrade. Sept. 28, admitted to base hospital. In great pain, lower abdomen tender and rigid; no history of vomiting; bowels had acted previous day, blood in motion; blood in urine drawn off by catheter. Examination: incised wound 1¼ in. long in outer and posterior part of left ischiorectal fossa. Laparotomy, same day, by Lieutenant-Colonel Hurley; clean-cut perforation of the antero-lateral aspect of rectum, shut off by adhesions; no gross leakage of bowel contents; wound in rectum sutured; hole in mesorectum also sutured. A clean-cut wound ½ in. long, non-perforating, on peritoneal surface of bladder; this extended as far as muscular coat; sutured. Bayonet wound was found at bottom of rectovesical pouch. Drain with split rubber tube and gauze to Douglas's pouch. Lithotomy position; perineal wound opened up, extended upwards and medially, striking inner surface of left pubic ramus, ¾ in. from mid-line. No extravasation of urine; blood-stained urine escaped freely from wound on introduction of finger to its depths; drained. Oct. 14, transferred to England eighteen days after operation, with few drops of urine still leaking from perineal wound during micturition.

Case 32 (1b).—Cpl. P., under care of Captain de la Cour. Wounded by shrapnel ball, Oct. 11, 1915. Entrance external abdominal ring on right side; missile extracted from left buttock near anus at field ambulance. Admitted C.C.S. same day; profuse hæmaturia, clots; had a large motion mixed with blood; temperature 101°; pulse 96. Admitted base hospital, Oct. 13. Temperature 102°. Abdomen tender, slightly rigid. Leaking slightly at anterior wound. Urine almost free from blood. Catheter tied in. Some ecchymosis of scrotum on right side; no swelling of testis. Gas- and fæcal-smelling stuff came through wound on right side and through catheter. Suprapubic cystostomy; large extraperitoneal cavity found, containing pus and fæcal-smelling material; pubic bone smashed at symphysis: this cavity communicated with rectum and with wound in left buttock. Oct. 17, transverse colostomy; temperature swinging to 103° in evening. Died Oct. 23.

Post-mortem.—Bladder badly lacerated; rectum opened; pubis smashed; cellulitis extended round cæcum to right renal region.

Case 33 (2b).—Lieut. M., under the care of Major Martin. Shell wound, May 2, 1916. Entrance wound right buttock, from which urine leaked. May 3, suprapubic cystostomy at C.C.S. May 16, very little urine from cystostomy wound; passing urine naturally; it contains a little pus and a fair amount of albumin. Temperature normal. No fracture. Evacuated to England doing well.

Case 34 (3b).—Pte. J. G., under care of Captain Morgan. Shell wounds, May 7, 1916. Two entrance wounds, one in right buttock and one internal to right anterior superior iliac spine; no exit. Fracture of iliac bone, complicated with severe compound fracture of both bones of right forearm and a wound of left leg. On admission to C.C.S.: vomiting; pulse 120; abdomen rigid and tender. Pure blood by catheter; swelling over lower abdomen due to extravasation of urine. Laparotomy by Captain D. C. Taylor, nine hours after injury; tissues infiltrated with urine; abdomen opened; no intraperitoneal lesion; peritoneum closed; bladder opened by suprapubic route; full of blood-clot; sponged out; laceration low down close to prostate; missile not found. May 5, amputation through arm for gangrene in forearm. Admitted base hospital, May 22. Patient pale, distressed, anxious; rapid respiration, and slight dyspnœa; had been running a high temperature at C.C.S. Urotropin given and bladder washed out. May 24, respiration rapid and difficult; sputum profuse, thick, and foul; pneumonia; urine oozing from buttock and other wounds. May 27, death.

Post-mortem.—Patches of pneumonic consolidation scattered throughout lower lobe of left lung, in places almost breaking down; congestion and some slight pleuritic adhesions at base; whole of middle lobe and upper part of lower lobe of right lung consolidated; at one part of middle lobe consolidated area breaking down; congestion at base; numerous pleuritic adhesions all over surface of right lung. Liver and spleen healthy. Kidneys: some passive congestion; pus in pelves. Track of missile passed through a series of abscesses, with purulent material in the space between them; foreign body perforated bladder twice extraperitoneally, levator ani, pelvic fascia, obturator internus, and lodged in pelvic aspect of ischial tuberosity.

Case 35 (4b).—Rfm. T. P., under care of Major West. Bullet wound, May 29, 1916. Entrance left buttock; no exit. On admission to C.C.S., condition good; severe abdominal pain and rigidity. Laparotomy by Captain Dew; nothing found but slight tear in peritoneum; per rectum, a large opening found in lower part of rectum; blood in bladder; iliac colostomy; suprapubic cystostomy; three pieces of bullet removed from bladder and one from left groin. Admitted to base hospital, June 3. Temperature 107·2°; suppression of urine; severe headache and backache; pulse 128. Later a little oozing of urine. Dry tongue. Drenching sweats after rises of temperature. Pallid. Listless; conscious. No uræmic fits. June 12, jaundiced; temperature still high; urine scanty. June 14, sordes on teeth; tremors; pulse small and rapid. June 15, died.

Post-mortem.—Pelvic cellulitis extending backwards and downwards from space of Retzius. No apparent renal trouble.

Case 36 (5b).—Pte. F. L., under care of Captain Morgan. Shell wound, June 13, 1916, right buttock. On admission to C.C.S., very collapsed, running pulse, great agony. Laparotomy by Captain Meyer; small fragment of shell found between rectum and bladder; one hole in left side of bladder; tear in peritoneal and muscular coats of pelvic colon, which was invaginated and sutured; finger passed into bladder; large foreign body found here; impossible to remove through existing hole in bladder; latter was therefore sutured; suprapubic opening into bladder; large foreign body, 1 in. long, removed; two other holes in lateral walls of bladder; impossible to suture these as patient was pulseless; bladder drained. Patient admitted to base hospital, June 20. Urine leaking from buttock wound. Evacuated to England a few days later.

Report from England.—March 23, 1917, removal of right testicle for abscess of four months' standing; both body and epididymis involved. April 12, large stone or "incrusted piece of shrapnel" removed by suprapubic route. July 5, wounds completely healed. July 11, discharge of pus from urethra; gonococci found. Patient had ear trouble which delayed his recovery. He was discharged as unfit for military service in November, 1917, about a year and five months after his injury.

Case 37 (6b).—Pte. P., under care of Major West. Wounded left buttock, June 27, 1916; nature of missile not stated. Admitted to C.C.S., June 28. Abdomen tender and rigid. Vomiting. Catheter drew off pure blood. Prevesical space opened up and found full of blood-clot; laparotomy; no intraperitoneal lesion; bladder drained by suprapubic route. On arrival at base, urine still flowing from buttock wound. July 4, death from pelvic cellulitis and sepsis.

Case 38 (7b).—Pte. B., under care of Captain Bryan. Shell wound, July 1, 1916. Entrance left buttock. Treated at C.C.S. by suprapubic cystostomy. On arrival at base, urine still flowing from wound in buttock. Corrected notes: Shrapnel wound from left hip to right iliac region; some shrapnel removed from bladder. (Shrapnel here probably means shell.—A. F.)

Report from England.—Some stricture at bladder orifice. Three stones in bladder crushed and removed. Sinus still persists from bladder to wound in right iliac region. Present condition: a good deal debilitated by prolonged suffering, etc.; is 40 years old, but appears more; has trouble with urinary sinus and often a good deal of pain. Quite possibly the stricture may give trouble in the future. Some cystitis and frequency of micturition. Recommended for discharge as permanently unfit. Sept. 9, 1917, discharged as no longer physically fit for war service, one year and two months after injury.

Case 39 (8b).—Sergt. C., under care of Major Menzies. Bomb wounds Sept. 9, 1916. Entrance left buttock; another wound in right upper extremity. No urine or fæces from buttock wound. At C.C.S., suprapubic cystostomy; metal removed from bladder; drain into bladder. Sent to base with catheter tied in. Arrived at base hospital with severe urethritis. Catheter removed. Urethra and bladder irrigated daily. Oct. 30, abdominal wound healed; voids urine normally. Nov. 4, evacuated to England doing well.

Report from England.—Urine still contained pus on Nov. 28; patient otherwise well. Posted to B.E.F., France, June 15, 1917, about nine months after injury.

Case 40 (9b).—Pte. F. H., under care of Captain Hamilton Drummond. Wounded by rifle grenade, Nov. 5, 1916. Entrance wound near middle line, 3 in. above pubis; no exit. On arrival at C.C.S. patient was in a condition of shock, and had vomited several times; a catheter drew off 10 oz. of blood-stained urine; per rectum, a foreign body, size of hazel nut, felt through anterior rectal wall. Laparotomy by Capt. Drummond; peritoneal cavity contained blood; one perforation of small intestine a foot from cæcum sutured; group of perforations 2½ ft. from cæcum; this damaged area of small gut was resected; bladder perforated almost in middle line, 1½ in. from peritoneal reflection; there was a wound of the rectovesical pouch made by the

missile as it passed through the bladder and out again ; at the bottom of this wound the missile could be felt lying on the rectum just below the peritoneal reflection ; missile removed ; finger introduced into bladder through entrance wound, and exit wound felt in the middle line behind the trigone ; Captain Drummond opened the bladder freely on its peritoneal aspect and dealt with the exit wound from within as described in text ; bladder was drained suprapubically after suture of intraperitoneal incision ; rectovesical pouch drained. Evacuated to England with small drain in bladder, doing well.

Reports from England.—Discharged on sick furlough Feb. 2, 1917. Discharged from the service on June 6, about seven months after injury.

Case 41 (10b).—A. B. McK., under care of Captain Kelly. Wounded, Nov. 13, 1916. Nature of missile not stated. Through-and-through wound from right groin to right buttock. At C.C.S., right testicle removed. Rami of pubis on right side fractured. Urine leaking continuously into wounds. Admitted into base hospital Nov. 18. Two days later pain in chest, pleuritic friction and tubular breathing at bases of lungs. Nov. 22, died.

Post-mortem.—Extensive fracture of horizontal and descending rami of pubis involving symphysis ; anterior wall of bladder torn away, hole admitted four fingers. Lymph on both pleuræ ; patchy consolidation at both bases and axillary aspect of left upper lobe.

Case 42 (11b).—Pte. R. W., under care of Major McEwen. Shrapnel ball wound, April 9, 1917. Entrance left buttock. At C.C.S., laparotomy ; a little free blood in peritoneal cavity ; large extraperitoneal hæmatoma in suprapubic region ; shrapnel ball removed from side of bladder in this area ; suprapubic cystostomy. April 21, arrived at base hospital. Abdominal wound infected ; urine flowing from suprapubic wound. April 28, leakage ceased. Evacuated to England a few days later, doing well.

Case 43 (12b).—Pte. A. V. C., under care of Captain Main. Bullet wound, April 4, 1917. Entrance right iliac region ; no exit. Missile had passed back, injuring right lateral extraperitoneal aspect of bladder, and lodged at interval between 1st and 2nd sacral foramina of left side near the bone ; large extraperitoneal hæmatoma. At C.C.S., suprapubic cystostomy. Admitted base hospital on April 11. Sloughing of scrotum. Suprapubic wound covered with phosphates. A few days later a large slough like a cast of the bladder came away on washing out the latter. May 1, evacuated to England, doing fairly well.

Report from England.—Patient up and about on July 27 ; wounds healed, but patient thin and anæmic ; frequent micturition, pus in urine. Aug. 6, improving. Still some pus in urine on Sept. 8. Oct. 22, fairly well. Nov. 15, discharged medically unfit about six months after injury.

Case 44 (13b).—Cpl. J. F. B., under care of Captain Morgan. Bullet wound, May 3, 1917. Entrance wound just to left of middle line in suprapubic region, one inch above pubis ; missile passed through anterior wall and right side of base of bladder ; exit, right buttock ; margins of obturator foramen smashed. Hæmaturia. At C.C.S., wounds cleaned and drained ; bladder drained suprapubically. May 10, on admission to base hospital, general condition poor ; patient septic, restless, incoherent ; anterior operation wound clean ; no urinary fistula in suprapubic region, but urine flowing from foul wound in buttock ; a good deal of blood-stained urine coming per urethram ; temperature 103° ; pulse 128 ; tongue coated with yellow fur, sordes on teeth ; paralysis of right sciatic nerve. May 12, *B. sporogenes* grown from blood ; gas gangrene of glutei and psoas muscles of right side ; patient a coppery colour. Died same day.

Post-mortem.—General gas infection.

Case 45 (14b).—Pte. H., under care of Captain Wilgress. Shell wounds, June 6, 1917. Entrance right buttock ; also multiple wounds of thigh and buttock. At C.C.S., laparotomy ; intraperitoneal wounds of bladder and rectum ; bladder and rectal wounds sutured ; foreign bodies removed ; abdomen closed ; suprapubic cystostomy. Name of surgeon who operated at C.C.S. not stated. June 18, arrived at base hospital. Suprapubic drain blocked, dressings soaked ; slight distention of abdomen ; slight general rigidity of abdominal wall ; bladder foul ; suprapubic wound discharging ammoniacal urine with muco-pus and gritty material ; patient collapsed and sweating ; vomiting ; laparotomy wound red, with superficial suppuration ; entrance wound in buttock discharging pus. June 23, fæcal fistula in buttock. June 26, piece of clothing and metal removed from thigh. July 4, intestinal obstruction. Major West thought the obstruction was in region of wound of rectum, and performed transverse colostomy. Death same day.

Post-mortem.—Obstruction due to adhesions between small intestine and the sutured wound in rectum ; intestines at this spot matted together ; interior of bladder foul, inflamed, and encrusted with phosphates ; the hole in bladder could not be found.

Case 46 (15b).—Pte. K., under care of Captain Palmer. Bullet wound, July 13, 1917. Entrance left buttock ; no exit. Fracture of pubic bone ; urine leaking from small wound in buttock ; bladder apparently full ; ecchymosis of abdominal wall, penis, scrotum, and perineum. Operation in base hospital same day ; attempt to empty bladder by catheter failed owing to blocking by blood-clot ; suprapubic cystostomy ; urinary extravasation ; two holes in bladder in anterior wall, one on either side of urethral opening ; that on right side led to a hole in pubic bone in which bullet was found ; perineal incision made, and perivesical space drained by

two tubes, one going towards bladder and one towards the entrance wound in the buttock where there was a collection of fluid; suprapubic wound sutured in layers, leaving an opening for a small tube which drained the bladder. July 19, suprapubic tube removed. Aug. 6, evacuated to England; temperature had been normal for a fortnight, and patient had been passing urine normally for eight days.

Report from England.—Urine leaked a little from perineum for some days, but this wound was dry on Aug. 22. Sept. 1, perineal wound healed. Sept. 15, lower end of epididymis swollen, hard, and tender. Dec. 8, urine contained much albumin and pus; frequency of micturition. Dec. 17, cystoscopy showed two small calculi in bladder; these were removed by litholapaxy, Dec 19. Note dated Jan. 7, 1918, states: "This man has made a good recovery, and will be ready for discharge from hospital in about two weeks."

Case 47 (16b).—Sergt. M., under care of Colonel Elder. Wounded by shrapnel ball, July 31, 1917. Entrance wound right buttock; no exit. Admitted base hospital, next day. Abdomen rigid; dullness in flanks; pulse 112; temperature 101°; considerable shock. Patient says he has not voided urine since injury. Catheter drew off a small amount of blood-stained urine, and a fragment of cloth was stuck in eye of catheter. Operation same day by Colonel Elder; suprapubic incision struck a large quantity of bloody fluid with urinous odour in the perivesical tissues; also free gas without fæcal odour; bladder opened, and shrapnel ball with some cloth removed; entrance wound of missile into bladder could be felt on right posterior aspect near the trigone; suprapubic rubber drain into bladder; laparotomy in right semilunar line at level of umbilicus; bloody fluid, smelling of urine, escaped; peritonitis, with exudate all over the coils of bowels; no injured intestine; abdomen closed. Temperature never rose above 101°, and pulse, which had gone up to 140 after operation, came steadily down. Patient began to pass water on Aug. 17, four days after removal of suprapubic tube into bladder. Evacuated to England, with urine still leaking from suprapubic wound.

Report from England.—On arrival at a military hospital urine was draining through wound, and patient unable to void per urethram. In the fourth week of treatment (at this hospital), one week after removal of a tube (which had been inserted after patient's arrival), patient was able to void ten ounces of urine at a time, and the bladder wound was practically healed. "There was some loss of bladder wall; much loss of fascia and muscle adjacent to wound through sloughing. Uneventful recovery; no sequelæ." Later note states that the patient joined a battalion on Nov. 29, about four months after injury.

Case 48 (17b).—Pte. K. McQ., under care of Captain Palmer. Bullet wound, Sept. 20, 1917. Entrance wound at coccyx; missile passed through rectum and bladder, and out through suprapubic region. At C.C.S., suprapubic cystostomy and iliac colostomy; coccyx injured. Oct. 18, passing most of urine per urethram; urine had leaked from rectum and suprapubic wound. Nov. 17, wounds almost healed; down for evacuation.

Case 49 (18b).—Bomb. P., under care of Captain P. N. Vellacott. Shell wound, Oct. 11, 1917. Entrance left buttock. Urine escaped from buttock on micturition. On admission to base hospital, bruising of scrotum and perineum. Captain Vellacott tied in a soft catheter. Rectal examination disclosed a foreign body on left side of middle line in front of rectum. Oct. 13, perineal section; urethra not opened; foreign body found lying against wall of bladder; opening in bladder not felt; the foreign body was large and irregular, about 1 in. long; no bone or bowel injury discovered. Catheter became blocked. Oct. 17, suprapubic cystostomy; Guyon's catheter introduced. Urine leaked from buttock and perineum. Evacuated to England, Oct. 28.

Report from England.—Nov. 2, wound in left buttock discharging fæces for first time. On Nov. 19, this had ceased. Nov. 21, passed a small quantity of urine naturally. Dec. 18, suprapubic wound dry. Dec. 20, perineal wound discharging freely. Jan. 28, 1918, patient is still in hospital,

Case 50 (19b).—Lieut. J. R. B., under care of Major Ranking. Wounded, Aug. 16, 1917, nature of missile not stated. Entrance, right groin; pubic bone fractured and spermatic cord divided; missile tore a large hole in anterior wall of bladder, and passed through sacrum. At C.C.S., ligature of cord and removal of testicle; suprapubic cystostomy. Fæces and urine from posterior wound. Sept. 2, fæces from anterior wound. Sept. 30, suprapubic wound dry, but urine still leaks from groin; urine also passed per anum. Oct. 10, passing some urine naturally. On evacuation, Oct. 11, most of the fæces coming per rectum and all the urine by rectum or groin.

Case 51 (20b).—L.-Cpl. W. F., under care of Captain Bush. Bullet wound, Oct. 17, 1917. Entry just anterior to left great trochanter. Note from C.C.S.: Bladder explored extraperitoneally; found injured; prostatic urethra completely divided at neck of bladder; blood in space of Retzius; bladder opened by suprapubic route and drained. Oct. 20, admitted to base hospital. Radiography shows fracture of ascending ramus of pubis, and bullet 1 in. behind neck of right femur. Pain in left thigh and leg (anterior crural nerve). Tender in perineum. Tube in space of Retzius not draining well. Urine very ammoniacal. Oct. 22, temperature 102°; pulse 112. Perineal section; on separating sphincter ani from bulb of urethra large space opened up, containing old blood-clot, urine, and a very small amount of fæcal matter; rami of pubis found fractured on both sides; prostate shattered, urethra torn from neck of bladder; catheter led into

bladder, and drainage tubes from each side towards rami of pubis; examination of wound of entry revealed some guttering of anterior surface of great trochanter; Carrel's tubes. Oct. 23, temperature 102°, pulse 120; patient says he is much more comfortable and free from pain. Nov. 1, died of bronchopneumonia. No post-mortem.

Case 52 (21b).—Pte. A. J. L., under care of Captain Sampson. Wounded by shrapnel ball, Oct. 4, 1917. Entrance left buttock near middle line; coccyx injured; missile perforated posterior and anterior walls of rectum, passed through peritoneal cavity, posterior and anterior walls of bladder, and came to rest beneath skin of suprapubic region, where it was found and removed. Laparotomy on day of injury; peritoneal perforation of rectum and bladder inaccessible; shut off by line of sutures across pelvic floor; drain into Douglas's pouch; suprapubic cystostomy. Oct. 6, iliac colostomy. Nov. 5, tube removed from bladder. Urine passed by natural passage about five weeks after operation. Nov. 19, admitted to base hospital. Still leaking from suprapubic wound. Cystoscopy; see text and *Fig.* 22. Per rectum, a linear oblique scar on anterior and posterior walls of rectum about a finger's length from anus. Dec. 15, fæcal fistula closed by extra-peritoneal method; sinus leading to bladder curetted. Dec. 20, some leakage of fæces. Dec. 24, suprapubic wound dry. Feb. 7, 1918, fæcal fistula almost closed; no urinary symptoms. Patient quite well.

Case 53 (22b).—Gnr. B., under the care of Captain Fletcher. Shell wound, Dec. 11, 1917. Entrance left buttock (*Fig.* 10). At C.C.S., slight trace of blood found in urine removed by catheter. Patient could pass no water during first two days. No leak from buttock wound. On admission to base hospital, no urinary symptoms. Dec. 15, urine contained albumin and blood-cells, but no pus. Dec. 23, frequency of micturition commenced; urine now contained albumin, pus in quantity, and scanty red cells; radiography showed fracture of sacrum, and foreign body 3¼ in. from back on left side near middle line, at level of 4th sacral vertebra; cystoscopy has been described in text (*Fig.* 23); per rectum, thickening in neighbourhood of left vesicula seminalis. Dec. 24, suprapubic cystostomy; foreign body felt in pocket of wall of bladder; removed through bladder; suprapubic drain. Jan. 15, 1918, passed urine naturally. Has been washed out regularly with nitrate of silver solution. Jan. 28, urine free from pus. Feb. 1, out of bed; wound quite dry; no urinary symptoms. Feb. 9, evacuated to England, quite well.

Captain D. C. Taylor has kindly forwarded notes of a case recently operated on by him. They illustrate so well one type of injury and its successful management that I have thought it well to introduce them here.

L.-Cpl. M. was hit with shell, Nov. 18, 1917. Entry wound right buttock near middle line. On admission, pulse 120, abdomen rigid, vomiting. Radiography showed two foreign bodies, probably in bladder. Laparotomy: no intraperitoneal injury; peritoneal cavity closed; much extravasation of blood and urine round bladder; latter opened, and two large pieces of metal removed; bladder washed out with saline and closed; tube to space of Retzius; foreign body had entered just to left of urethral orifice, after passing through left lobe of prostate; buttock wound opened up; track found to pass through anterior and posterior walls of rectum. Patient, unfit for further operation at this time, sent back to bed and catheter passed every six hours. Twenty-four hours later, urine found leaking per anum and through buttock wound; incision in front of anus, and rectum separated from urethra; small tube inserted into track and stitched in position. Five days later tube removed. Twelve days after operation, all urine passed per urethram. One month later, patient wrote to say that all wounds were healed, and he was walking about without any symptoms.

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UNUNITED FRACTURES OF THE MANDIBLE; THEIR INCIDENCE, CAUSATION, AND TREATMENT.*

By PERCIVAL P. COLE, London.

The relative incidence of ununited fracture of the mandible as compared with other bones is difficult to assess, because, so far as I am aware, no published figures are available. From my own experience, in general military as well as in jaw surgery, I should conclude that non-union occurred more frequently in the lower jaw than in any bone of the extremities. Several factors determine the occurrence of this higher incidence: a corresponding degree of destruction in the case of the extremities would frequently lead to amputation; approximation with such loss of tissue as would give a good result in the case of a limb would result, in the jaw, in such deformity and hopeless loss of function as to render this procedure impracticable; the superficial areas of the fractured surfaces are, particularly in some situations, small as compared with that of the humerus, femur, or tibia.

The discussion of methods adopted in the ordinary routine treatment of fractures of the mandible is outside the scope of this contribution. This point is to be emphasized, in that our procedure is in important respects at variance with that advocated and practised by accredited authorities, both in this country and abroad. To define our aims is, however, not only relevant but necessary, because their validity is intimately associated with the question of non-union. There exist two schools whose views on this subject are widely divergent. The one maintains that bony union is of paramount importance; that correct alinement is incompatible with union in cases associated with loss of substance; and that therefore deformity of varying degree must not only be tolerated, but deliberately produced, to the end that bony union may be obtained. The other school is equally alive to the importance of bony union; it holds, however, that correct alinement should be determined in every case, and strongly deprecates the passive acceptance of a doctrine of deformity as theoretically unsound and practically unnecessary.

It is to be noted that this divergence of views is confined to the type of fracture associated with what is indefinitely called 'moderate loss of substance.' No difference of opinion exists with regard to fractures unassociated with loss of substance, for apart from details in the mode of treatment the question of the ultimate aim obviously does not arise. This is equally true in the case of fractures associated with such great loss that any attempt at approximation is impossible or would lead to hopeless loss of function and extreme disfigurement.

The fundamental principle that shapes the procedure of what may be termed the 'ideal' school is the restoration of the normal arch and the maintenance of accurate occlusion. It is on these lines that our cases have been treated at the King George Hospital. Stress of work has at times forced us to adopt temporary expedients, with unavoidable lapse from planned perfection. Apart from these failures, negligible both in number and degree, every patient discharged has been sent out with a normal arch and normal occlusion. The figures now brought forward have been arrived at by a careful survey of cases treated by Mr. C. H. Bubb and myself at the King George Hospital. The numbers are exclusive of cases sent to us for plastic repair and of those transferred to us from other sources with residual non-union. In a word, they are patients who have come under our care immediately or soon after the infliction of their injury.

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* Hunterian Lecture delivered before the Royal College of Surgeons on Feb. 8, 1918.

We have thus dealt with 270 cases. The total of ununited fractures numbers 30, or approximately 11 per cent. Of the 30 cases, the possibility of union in 12 was absolutely hopeless, judged by no matter how exacting a standard. The resulting exclusive figure is therefore approximately 7 per cent. I maintain that these figures, apart from the means at our disposal for the rectification of non-union, are ample vindication of 'ideal' aims. Our adherence to these aims has been made known on several previous occasions. Reasons for this attitude will be indicated in considering the causes of non-un on.

In considering causation, the constitutional factor, and the presence of undue mobility, may with propriety be eliminated. Non-union is then due to :—

1. Primary loss of substance.
2. Secondary loss of substance due to necrosis.
3. Interposition of muscle, fascia, or other connective tissue.
4. Presence of a central sequestrum. This is a rare cause of non-union. There may be no other indication suggesting the presence of a sequestrum. It has occurred twice in our series. In one case non-union persisted; in the other apparently firm union gave way when subjected to normal stress.

The results produced by one or other of the first three causes are (1) fibrous union, (2) pseudo-arthrosis. Pseudo-arthrosis entails bony contact, with the formation of a true false joint, with surrounding adventitious capsule. I have only once seen anything approaching this condition, and for practical purposes it may be ignored.

Consideration may reasonably, then, be confined to the causation and nature of fibrous union. In comparing the repair of bone with that of other specialized connective tissues, one striking fact emerges. Bone differs from all other connective tissues in this important respect, that solution of its continuity is made good by the formation of a cementing substance which exactly reproduces its own structure. In the case of other tissues, irrespective of their nature, the bond of union is fibrous tissue. It is here maintained that the converse holds true—that the presence of fibrous tissue is clear evidence that the reparative process has been determined as a result of the reaction to injury of tissues other than bone. We are not here concerned with extraordinary examples of metaplasia, but with the ordinary routine phenomena that occur in the repair of connective tissue.

Viewed in this light, the name 'fibrous union,' as referring to bone, is a gross misnomer. It is a name given to a condition in which union of bone has been prevented by the interposition of the reparative products of surrounding extraneous connective tissues, or of these tissues themselves. As will be shown later, periosteum itself is included in those tissues the interposition of which constitutes the factor preventing union. It will be corroborative and advantageous to examine this view in the light of clinical and experimental data relating to the behaviour of fractures under varying conditions. The only established limit to the growth of bone is that which is determined by the satisfaction of functional demands. Bone will be laid down until equilibrium is established between functional liabilities and assets. This potential power of repair by growth has long been recognized. It has found expression in many ways, among which may be mentioned " the crystallization of the lines of force," in the picturesque phraseology of Sir Arbuthnot Lane, or the law of adaptation to function, as laid down by Wolff and Roux.

It may then be safely assumed that in the ordinary healthy individual bone possesses sufficient regenerative power to make good any defect caused by injury, provided that the conditions are such as to give the best possible effect to factors which favour the process of regeneration. These are considered to be :—

1. Prevention of interposition.
2. Restoration or preservation of that stress which is the normal stimulus to the growth of bone.

It is contended that the determination of bony union depends upon these factors, and that the successful treatment of non-union is only attained by measures designed to ensure their effective application.

A review of the fate of fractures associated or not with loss of substance will serve to determine the truth or otherwise of this contention. In the case of the ordinary fracture

without loss of substance and with little or no displacement, both conditions are determined by the contact of the bony fragments, and this without regard to the rôle of the periosteal sheath. In such a case bony union may confidently be expected. Should, however, lateral displacement occur so that the ends of the fragments overlap, union or otherwise will depend on the conduct of the periosteum. If this strips readily, the displacement will take place within an intact periosteal sleeve or bridge, and union will occur with considerable deformity. Should, however, the periosteum be densely adherent to one or other fragment, it will tear instead of strip, and so accompany that fragment in its excursion to the position of displacement. In this situation it will—together perhaps with any muscle fibres attached to it—become an interposing agent, and thus prevent union. This interposing action of the periosteum is in full accord with the rôle assigned to it by Macewen, and later confirmed by Hey Groves, as being essentially a limiting membrane to bone.

Such interposition is of particular importance in that it accounts for the occurrence of many cases of non-union of fractures of the mandible without any, or with but little, loss of substance. The facts as here cited have been verified by direct inspection of cases treated for non-union by operative measures. A large proportion of cases of non-union occur in the neighbourhood of the angle, immediately in front of the attachment of the masseter, the facial vessels being in intimate proximity. The posterior fragment is always much more difficult to expose and clear than is the anterior. This is partly due to the presence of the masseter, and partly to the greater depth of the fragment; but also to the fact that whereas the periosteum on the anterior fragment strips easily, that on the posterior fragment is densely adherent, particularly along the lower margin of the jaw. I have been able to observe on several occasions that though there had been no loss of substance—in some cases even an overlap—the posterior fragment with its attached periosteum and masseter had been carried inwards, thus determining interposition, with resulting 'fibrous union.' This condition is illustrated in *Fig.* 25.

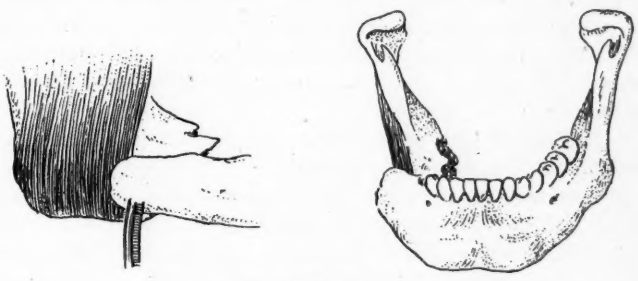


FIG. 25.

Reverting to the question of contact, it will be obvious that a broad area of contact will not be necessary to prevent connective-tissue junction between the fractured ends, and that a very limited contact should be sufficient on theoretical grounds to determine firm bony union. This limited contact has, indeed, been found practically to suffice, a fact which has been particularly emphasized by Sir W. Arbuthnot Lane in a recent contribution on the operative treatment of fractures in war time.

The question of union in fractures associated with loss of substance depends on the amount of loss, the condition of the periosteal sheath, and the presence of comminuted bone fragments.

Clinically, primary loss of substance cannot occur with the periosteal sheath intact. Experimentally, Hey Groves has shown that, with a section of the whole bone removed and periosteal sheath intact, union rarely occurs, and is then due to the presence of bone cells adherent to the membrane and detached with it by deep stripping. It is suggested that in the cases with non-union, the periosteum played the part of ordinary connective tissue, prolapsed into the gap and united therein (*Fig.* 26). In the cases with union, the periosteum *per se* played the part of excluding connective-tissue invasion from the exterior while the bone-forming elements on its inner surface proliferated. Bony

FIG. 26.

contact there unquestionably was not. Continuity of bone-forming elements, with exclusion of alien activity, there certainly was. The beneficent part performed by the periosteum in the union of fractures is more frequently that of a membrane limiting and excluding connective tissues than a membrane limiting and including bone.

That bony union may occur with considerable loss of substance, not only in the mandible but in other bones, is clinically established beyond all doubt. In the mandible, cases have been cited by Stephens, Doubleday, and others, and many of our own cases establish the same fact. These may well be explained by the excluding disposition of the periosteum on the one hand, and by continuity of bone-forming elements attached to the periosteum on the other. The bone-forming elements may be such as to give no *x*-ray evidence of their presence, or may exist in the form of demonstrable comminuted fragments. The condition may be diagrammatically represented as in *Fig.* 27. As Sébileau has so pertinently observed: "I have seen apparently straightforward fractures, particularly at the symphysis and at the angle, preserve their original mobility for many months—some of them, in fact, did not consolidate; and, on the other hand, fractures with widely-separated fragments cicatrize by means of thick and resistant bridges of osteo-fibrous tissue in a few weeks."

FIG. 27.

It is because union cannot be guaranteed where no substance has been lost, because, conversely, union does not necessarily fail where loss of substance is considerable, and because the vast majority of war fractures of the mandible do not exhibit clean-cut loss, but rather a condition of extreme comminution, that we have from the first espoused and rigorously carried out the 'ideal' treatment.

Comminution has an important bearing on union. Clinically, it is established that such fractures, even when compound, unite in a manner that is surprising, both as regards firmness and rapidity. Hey Groves, in his experimental work, has demonstrated this fact, and made it the subject of express comment.

The remedial measures undertaken to combat non-union show clearly how predominant are the factors previously cited. Vigorous friction of the bone ends upon one another is a proceeding of classical antiquity, and is frequently attended by successful results. Success is attained in a two-fold manner. First, the fibrous junction between the bone ends is broken down by mechanical force; secondly, the real traumatic contact of the bone ends thus brought about stimulates proliferation of bone-forming elements. The narrowest bony union thus established is increased by growth, naturally evolved in response to functional demands. It is obvious that full reconstitution in such a case is a matter of time, and it is probable that many cases of so-called delayed union are capable of explanation on the lines indicated. Remedial measures, however, of this nature can be effectual only where loss of bone is small and fibrous interposition correspondingly limited.

Where loss is considerable, the only method hitherto available whereby bony continuity without deformity can be established is by a bone graft. In view of the ease with which an autoplastic graft can be obtained, and its superiority as demonstrated both experimentally and clinically, it will be unnecessary to consider grafts of the homoplastic or heteroplastic variety. That bone-grafting is established as a successful clinical proceeding there can be no doubt. This being so, it will be pertinent to determine what are or are not the essential physical properties of the graft that make for success. That this does not depend on the presumed vitality of the tissue utilized is clearly demonstrated by the work of Hey Groves and Albee. Hey Groves has testified to the fact that results similar in nature, and differing only in degree, can be obtained by the use of boiled bone. He goes so far as to maintain that "a graft of dead bone (boiled), properly fixed by metal sutures, will give a better result than a living autogenous graft fixed by catgut alone." Albee has successfully utilized grafts from bone kept in cold storage.

A great deal has been talked and written about the re-establishment on the part of

the graft of what is loosely called 'fresh vascular connections.' If this means anything, it means that through the original vascular channels of the graft blood derived from neighbouring vessels circulates anew; that the graft is nourished by such circulation in precisely the same way as before its original vascular connections were severed; and that it is as a result enabled to preserve its individual characters as a living active entity.

Considerable light is thrown on this question by consideration of the fate of free bone-grafts embedded in vascular tissues, by the results obtained on endeavouring to transplant a bony implant, and by the behaviour of free grafts of other connective tissues when used to remedy such defects as depressed scars. It has been established beyond cavil that the fate of free bone implanted into soft tissues, no matter how vascular, is gradual absorption (Phemister, Davis, McWilliams). A deliberate and conscientious attempt has been made by Imbert and Réal to remedy bony defects in the mandible by transplanting into the gap sections of bone previously implanted in the neighbouring soft tissues. Such attempts were made with the idea that the graft would be more likely to succeed after its nutrition had been definitely determined by the establishment of fresh vascular connections. They found, however, that transplantation had to be undertaken in not more than three or four weeks. If longer time elapsed, the graft was found to be so softened that effective fixation could not be attained. In all cases, the result as regards bony union was a complete failure.

A similar initial attempt of my own may be cited, undertaken at a time when my ideas on the subject were befogged by misapprehension, undoubtedly begotten of the loose phraseology employed. About eighteen months ago it occurred to me that transplantation of an implant would not only solve the problem associated with many bony defects with coincident loss of soft parts, but would permit plastic operation and bone-grafting to be undertaken at the same time. To this end a large section of the crest of the ilium, measuring twelve centimetres in length, was implanted in the neck of a patient whose chin had been shot away together with the greater part of the body of the jaw. Owing to a severe hæmatemesis from which the patient nearly died, further operation was indefinitely postponed. Originally the bony mass formed a prominent projection in the neck. Its removal was decided upon owing to its marked and progressive diminution in size, and when removed a few weeks ago it was found to be, at most, one-fifth of its original bulk.

Further light is shed upon this question of vascularity by observations as to the fate of free transplants of other connective tissues utilized to make good defects of the soft parts. This measure is one that clinical experience has shown to be successful. I first employed musculo-fascial grafts as a means of filling out deforming depressions on the face. Fat grafts have been used in the same way. Acting on the false assumption, as I now hold, that these grafts established fresh vascular connections, it seemed reasonable to suppose that a small area of skin might be included in addition to the fatty and aponeurotic tissues. If structures on which skin depends for its nutrition were included, and if such structures became vascularized from the bed in which they were implanted, then surely the skin should live. The time factor was considered, but the hardihood of skin is notorious: the growth, even, of hair long after body death has occurred is testimony to this effect. The result was curious. For the first few days, except that the implanted skin was somewhat blue, all seemed well. This blue tinge is frequently seen in pedicled flaps, and was not, therefore, regarded as of specific importance. Gradually the blue deepened, a curious 'bogginess' became apparent on palpation, and finally the whole area became black, but no suppuration occurred. The whole mass was firmly held, the outer surface quite dry. Shrinkage gradually occurred, but there was no attempt at exfoliation. It was evident that in this case there had been no establishment of fresh vascular connections, and in the light of it other cases were examined more carefully. It was found that shrinkage had occurred, and that the area at the site of implant had assumed a hard inelastic consistency quite foreign to the substances implanted. It was impossible to conclude otherwise than that these free implants had been absorbed and

replaced. To what extent, if any, cellular proliferation had taken place in the graft, it was impossible to determine, but the ultimate result appeared certain.

Consideration of the results obtained by the use of free transplants of soft tissues leads then to the conclusion that these are absorbed and replaced, a view confirmed in the case of muscle by Serafini. Additional evidence is afforded by the fact that results equally successful have been obtained by the use of decalcified bone. The use of this devitalized absorbable material in the plastic surgery of the soft parts is exactly comparable to the use of boiled bone to remedy a bony defect Bone, then, behaves like other vascular connective tissues, and shares a like fate when transplanted into the soft parts. The cutting off of the blood-supply to such tissues leads to death in mass of the part affected. Death so occasioned rarely occurs in the body apart from septic processes, or occurs in such situations as lead at once to the introduction of septic factors. The only instance analogous to the condition of a free aseptic graft is that of infarction. Adami thus describes the resulting processes : " The central dead area becomes the seat of a progressive formation of granulation tissue. New capillaries pass in from the surrounding vessels and become clothed with fibroblasts until a new connective tissue completely replaces the dead tissue, and then, after the nature of new connective tissue, undergoes pronounced contraction, so that the end-result is the production of a dense depressed scar of firm connective tissue."

It is contended, therefore, that the establishment of fresh vascular connections is invariably determined as the result of an inflammatory interaction between tissues themselves possessed of active circulation. Bleeding has been noticed on section of a free bone graft when exposed some time after implantation ; injection of the limb has succeeded in showing in an inserted bone graft vascular channels obviously derived from the systemic circulation. This blood and these blood-vessels are, it is maintained, derived from and confined to the invading tissues. Obviously there is a profound difference between vascularization by invasion and vascularization by intercommunication.

That a fractured graft has shown evidence of union by bony callus is brought forward as incontrovertible proof of the vitality of that structure—proof, in other words, of vascularization by intercommunication. This phenomenon is, however, susceptible of quite another explanation. Invasion from the freshened bone end would occur, as diagrammatically shown in the upper diagram in *Fig.* 28. Fracture of the graft will liberate these invading elements, as shown in the lower diagram. Callus will be formed from the liberated contents of the graft, and not at all from the graft itself.

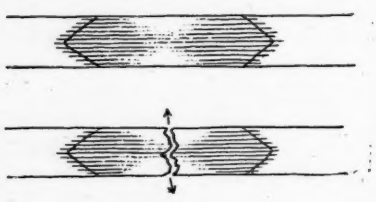


FIG. 28.

But, such happenings duly considered, there remains the fact that bony continuity can be determined by means of a bone graft, provided the graft is in suitable contact with the separated ends of the fragments. Davis has shown, however, that if one end only of the graft is in contact with living bone, the same result ensues as if no such contact was established. A bone graft only succeeds in determining the growth of bone when it is in intimate contact at each end with living bone, a structure the inflammatory products of which have the specialized function of reproducing a like tissue from which they emanated, as previously noted.

It is this intimate contact with living bone which dominates the whole field of bone-graft surgery ; it favours invasion of the graft by bone-forming elements derived from the living mother bone, and at the same time restores to the separated ends that stress which is the natural stimulus to the proliferation of such elements. Osteogenesis is favoured by the stress imparted by the graft to the mother bone, and not by that imparted by the mother bone to the graft. This view is alone reconcilable with the known fate of a graft implanted in soft tissues only. To reason that in the latter case atrophy takes place because the graft is functionless, implies a prescience on the part of that structure that the most rabid teleologist would hesitate to invoke. It would appear that bony continuity is established

by a process aptly termed 'creeping substitution,' and it is tentatively suggested that this process is somewhat analogous to that which occurs in the regeneration of nerve fibres following suture of a divided peripheral nerve. As regards the relation of the graft to the soft parts, it may be safely deduced from what has previously been stated, that the bone graft succeeds not because of any action of the soft parts upon it, but because of its action upon them. In other words, it prevents by continuity of mass the junction and organization of connective-tissue products in the gap. That continuity of mass is essential to success is shown by the fact that the insertion of fragmented bone does not determine union. This has been experimentally demonstrated by Hey Groves, who expressed surprise at the negative result obtained. Bone dust was found to be even more ineffectual. These findings are completely at variance with the vascular theory, confirmatory evidence of the truth of which would have been afforded by an exactly opposite result; smaller fragments must obviously be more easily vascularized than large.

It is clear that the introduction of such a devascularized body as a free bone graft into a septic environment will probably lead to its extrusion as a septic sequestrum. The first essential of the soft connective-tissue bed is, therefore, that it shall be free from frank or concealed sepsis. All that is required in addition is that the tissues shall be sufficiently pliable to permit nice adaptation of the graft, and sufficiently well nourished to maintain their vitality when sutured, and thus prevent the introduction of sepsis from without.

The bone graft, then, succeeds because it is permeable and absorbable; because it is enabled by continuity of mass to prevent organization of non-bone-forming connective tissues in the gap; and because it restores the stimulus of stress to the separated bone ends by virtue of its solidity. It succeeds, in a word, by establishing exactly those conditions which have been shown to be necessary for union in the case of all fractures, with or without displacement or loss of substance.

No mention has been made of the periosteum, because the presence of this membrane is not essential to the success of a graft. Davis, in the course of an experimental investigation to determine the relative permanence of free transplants of cartilage and bone, found that bone covered with periosteum was absorbed much more slowly than when stripped of this membrane. It would appear that periosteum included in a free transplant opposes an additional barrier to connective-tissue invasion, and with that view its preservation is indicated.

The attainment of union is undoubtedly important in so far as it fulfils a functional demand. There is, however, no academic virtue in union apart from this, and therefore the ultimate and only test should be a functional one: in the case of the mandible, the patient's ability to masticate ordinary foods. *X*-ray photographs will not supply this necessary information. Indeed, subjective must take precedence of objective signs, though the latter may determine a strong prima facie case. It is precisely this personal factor that renders the measure of functional disability so difficult to estimate. That non-union, used in the strict sense of the term, is not incompatible with perfect function is as certain as that in some cases of obviously sound bony union the ability to masticate hard foodstuffs is denied. Functional disability varies according to the site of the fracture. In the ascending ramus, the nearer the fracture to the condyle the less is the disability occasioned. Complete loss of the ascending ramus properly treated, gives rise to no functional disability whatever, as is evidenced by a case at one time under my care and now discharged. In the horizontal ramus, the disability increases the nearer the site of fracture approaches the symphysis. In general terms it may be stated that if both the masseters maintain attachment to one fragment, disability is relatively slight.

This functional estimate is obviously of importance from the point of view of treatment. It will be the deciding factor in determining the advisability of endeavouring by open operation to make good the functional defect. The extent of the functional defect and the improvement likely to follow operation should be duly considered. The operative result would appear to be somewhat of an unknown quantity. This is due partly to the distrust of such procedures which many dental surgeons display, and partly to the

detached attitude sometimes assumed by surgeons in charge of such cases. The attitude of the surgeon fosters the distrust of the dentist, who tends to adopt ultra-conservative measures, content to suffer present ill rather than adventure worse to follow. Progress in this, as in many other, issues associated with war injuries of the jaw and face, has been retarded by lack of proper collaboration between surgeon and dentist.

An endeavour will be made to present a fair, unbiassed account of cases of non-union coming under the joint care of my dental colleague, Mr. C. H. Bubb, and myself. The methods employed have been as follows :—

1. **Plating.**—(*a*) Plating alone; (*b*) Plating with interposition of fragmented bone.

Two cases have been dealt with, the lesion in both being non-union of a fracture of the ascending ramus. In the one case there was but little loss of substance; in the other the gap, after trimming the bone ends, was one and a half centimetres. Both cases were splinted, and no attempt was made to establish contact.

In the first case, a two-holed silver plate was used. The operation was done on March 9, 1917. The plate has not been removed, and gives no trouble. The use of a two-holed plate was mechanically unsound. Functionally, the patient is greatly improved. Seen on Nov. 2, he stated that he could eat crust if not too hard, and meat if not gristly. Partial success only is claimed for this case.

In the second case, a four-holed silver plate was used, the gap being strewn with bone fragments detached from the angle of the jaw. The plate was removed, not because it gave trouble, but because it was hoped that further consolidation might occur. As regards union, this case is a complete failure. Functionally, his occlusion is perfect (he has an almost complete set of teeth) ; there is little or no deviation on opening the mouth ; his direct bite is powerful ; but the grinding movement is considerably impaired.

Plating has a very small sphere of usefulness in ununited fractures of the mandible, owing to the fact that necessary contact cannot be secured without traction. Wire is difficult to use with fractures of the ascending ramus, owing to the fact that the deep aspect of the fragments is so inaccessible. It is an open question whether fractures at or above the middle of the ramus are not better left alone. If operation is decided on, a bone graft should be used if the defect is considerable. If the defect is very small, contact should be established by the plate-wire method described later.

2. **Wiring.**—(*a*) Buccal cavity opened ; (*b*) Buccal cavity not entered.

It sometimes happens that in cases of old mal-union with considerable deformity, the only possible method of dealing with the fragments is to wire them immediately. The mouth cavity is necessarily opened in the course of reduction, but the risk in such a case is worth taking. Only once, in my experience, has such a course been necessary. The wire was removed subsequently. The functional result is perfect.

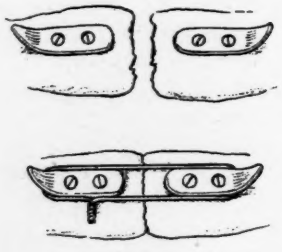


FIG. 29.

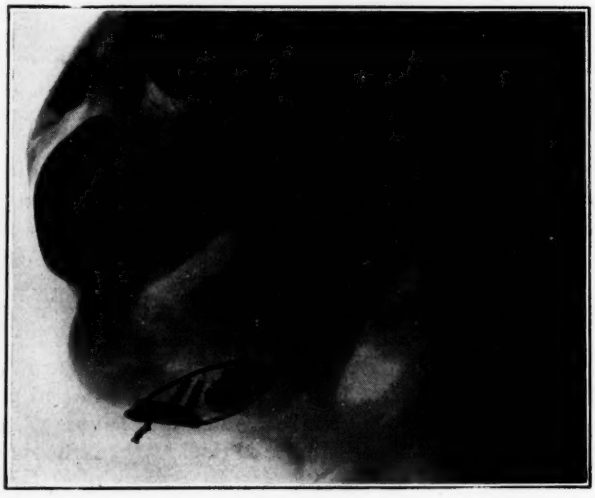


FIG. 30.

Cases suitable for wiring by the ordinary aseptic technique are those in which there is little or no loss of substance. As has been pointed out, these fractures occur in the neighbourhood of the angle. The posterior fragment is left free. The anterior fragment, if not edentulous, is splinted in correct alinement. When the lower jaw is edentulous no splint is used. Cases have been treated in this way with consistent success. Where wiring is practicable, success may reasonably be regarded as certain. The difficulty in wiring is to avoid opening the mouth while clearing the deep aspect of the fragments to permit the passage of drill and wire. I have lately devised and used a combined plate and wire method, the mode of application of which is illustrated in *Fig.* 29. The plates are first screwed into the fragments. The wire is then passed under their upturned outer ends. Traction on the wire brings the fragments into contact, and the wire is then twisted. *Fig.* 30 shows the plates and wire *in situ.*

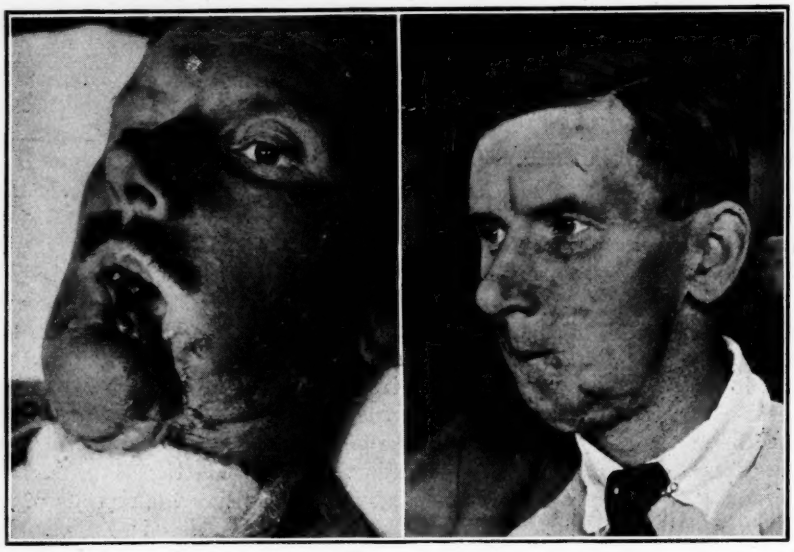
3. **Bone-Grafting.**—(*a*) Free autoplastic graft ; (*b*) Pedicled graft.

The position of the bone graft is the most vexed of all the problems associated with fractures of the mandible. Little enough has been written as to the success attending the use of bone grafts to remedy defects in the long bones. Still smaller are the available data with regard to its application to the mandible. Albee claims 100 per cent of successes, but his work is largely concerned with the treatment of recent fractures and the correction of spinal deformity. It is quite certain that nothing like this proportion of successes can be claimed when the object in view is the reconstitution of a bone which has suffered loss involving its whole thickness. As regards the mandible, the scantiness of effort, or at least the scantiness of success, may be judged by consulting the records of recent meetings. At the annual meeting of the British Dental Association in London, June, 1916, a special session was set apart for the consideration of this subject. No opening paper was read, because no one could be found willing to undertake the task. At the Medical Society of London, in December, 1917, the question was dealt with in a general way by Captain Kelsey Fry, but no details were given such as might lead to the estimate of results. This is scarcely to be wondered at when it is considered that only three or four out of one hundred cases with fractured mandibles either demand or are suitable for a bone graft, and also that months must elapse before the final result can be estimated. Eve reported five cases without indicating the results obtained. McWilliams, reporting six cases, urges that repeated operations may be required, and should be persisted in till the desired result is attained ; with that view I heartily agree. Lindemann has published a series numbering no less than 282 ; this colossal contribution suggests that the writer must have access to an enormous number of patients, or that the percentage of non-union must be very high. So extensive is the ground covered, and such is the time required to treat effectively the numerous lesions grouped under the heading of war injuries to the face and jaws, that concentration as regards cases of non-union might well be resorted to with good results.

There are certain peculiar difficulties associated with grafting in fractures of the mandible. The exposure of the fragments is always attended with a certain danger of opening the mouth. This danger is, I think, exaggerated. It has only happened to me once, and the operation was then promptly abandoned. The relatively small size of the bone, especially in old fractures, and the necessarily restricted area in which to work, are difficulties much more formidable. Elaborate dovetailing is practically impossible, and I feel sure that people who reproduce diagrams illustrating such a procedure can never have attempted the operation on the living subject.

The necessity for the employment of a free graft presupposes loss of tissue of some extent. Such loss is frequently associated with coincident damage to the soft parts, with the formation of a buccal fistula of varying dimensions. The possibility that a graft may be required must be borne in mind from the time treatment is begun. The necessary plastic operation must first be performed. This includes closing the fistula and elevating the soft parts, to prevent their adhesion to the bone in the neighbourhood of the gap, and to provide a sufficient thickness of soft parts to accommodate the graft. The procedure will best be illustrated by the consideration of a concrete case. *Fig.* 31 shows the condition

of a patient immediately before the plastic operation was undertaken. A suitable splint was adapted to retain the fragments in correct position. A wide exposure of the area was then obtained by free reflection of the soft parts. The ends of the fragments were



FIGS. 31 and 32.—Patient before the plastic operation and after recovery from plastic operation, and before insertion of the graft.

exposed, and the mucous membrane of the floor of the mouth was dissected up and united to the mucous membrane of the cheek. Under cover of this the bone ends were shut off from the buccal cavity, and between them was inserted a piece of decalcified bone. The soft parts on the outer aspect of the bone were brought together in such a way as to raise the corner of the mouth. Counter-drainage through a stab wound was estab-

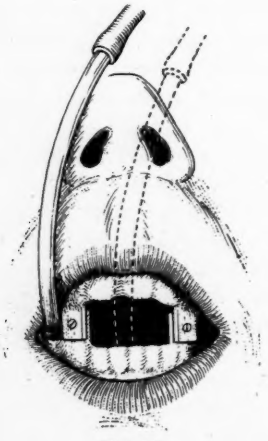


FIG. 33.

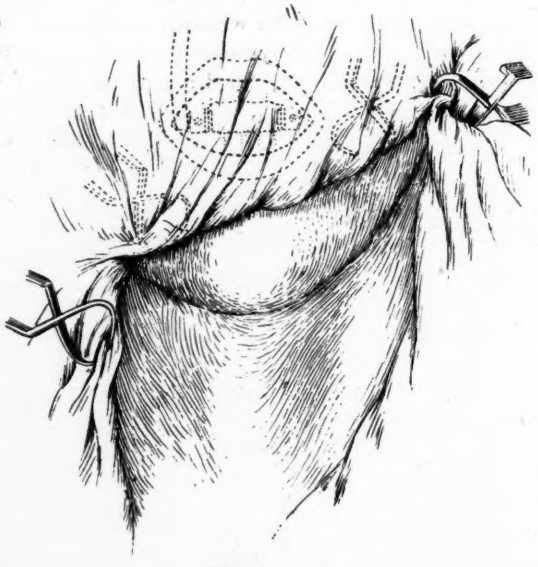


FIG. 34.

lished. The parts healed uneventfully. Nutrition was promoted by radiations and massage, and the patient is now ready for the insertion of the graft (*Fig.* 32). In order to eliminate the possibility of infection from latent sources of sepsis an interval of three months is allowed to elapse in such a case before the grafting operation is undertaken.

The technique of this operation is as follows: Two or three days previously, upper and lower cast-metal cap-splints are cemented in place. These splints are provided with bilateral overlapping threaded flanges which, when fixed together by screws, determine the position of the fragments in correct alinement (*Fig.* 33). When the patient is on the operating table these screws are removed, allowing the mouth to be freely opened for the passage of the intratracheal catheter. As soon as the catheter is passed, the screws are replaced. It will be noticed that the jaws so disposed are in the open bite position. This position is essential if intratracheal methods are employed. The anæsthetist is then isolated from the operation area (*Fig.* 34). A curved skin incision extending well into the neck is now made, and a flap turned up to expose the site of the fracture (*Fig.* 35). Bleeding vessels are ligatured and towels clipped to the skin margins. The ends of the fragments are then exposed, cleared, freshened, and shaped for the reception of the graft (*Fig.* 36). The graft, taken as a rule from the tibia, is now cut, the length and shape being determined by the use of calipers and a pattern cut in sheet lead. The plates are screwed to the graft before the detaching cross-cuts are made (*Figs.* 37, 38). The graft with detached plates is then transferred to its destined site and fixed in the gap by two screws attaching each plate to the corresponding fragment of the fractured mandible (*Fig.* 39), and the wound sewn up (*Figs.* 40, 41). A similar technique is adopted when rib is employed (*Figs.* 42, 43).

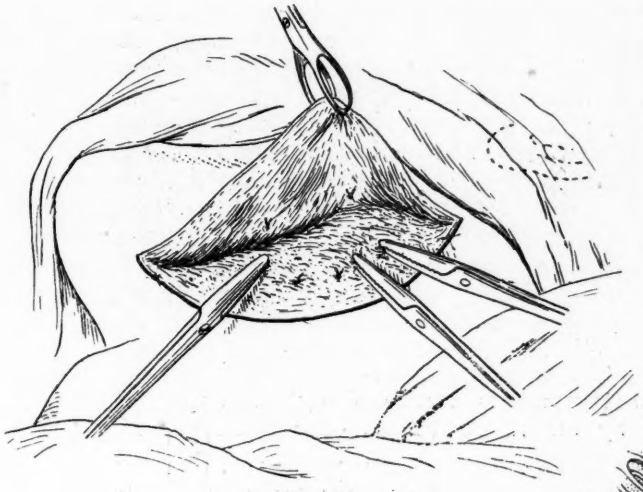


FIG. 35.

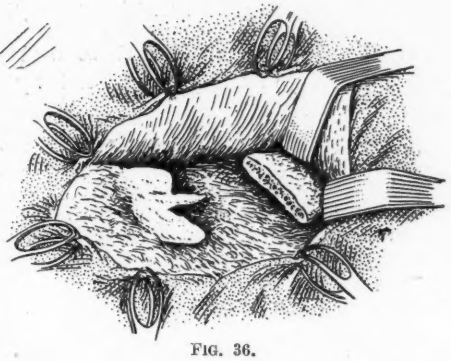


FIG. 36.

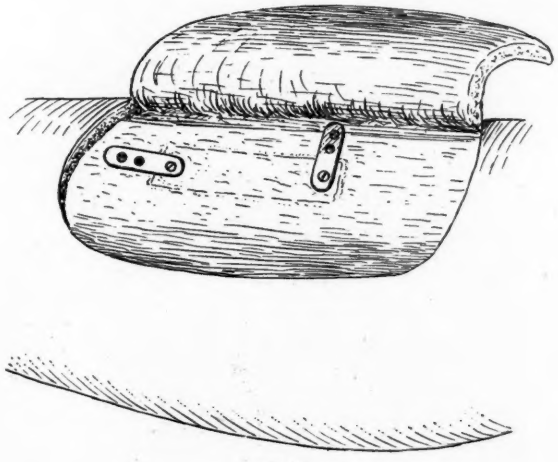


FIG. 37.

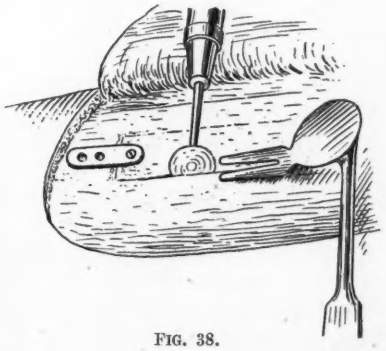


FIG. 38.

We have always acted on the assumption that fixation of the fragments and fixation of the graft are conditions essential to success. A considerable experience in the operative treatment of fractures of the long bones by metallic fixation entirely negatives the view

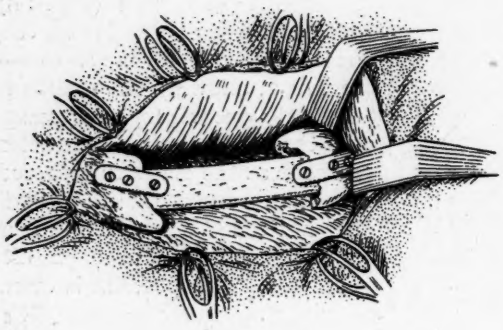


FIG. 39.

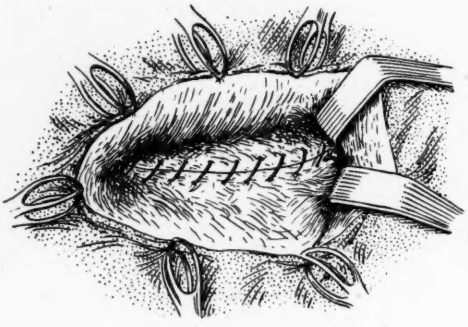


FIG. 40.

that any serious impediment to osteogenesis is occasioned by metal used in this way. This view is strongly supported by Sir W. Arbuthnot Lane and Major Hey Groves. The latter, in his Jacksonian Prize Essay, concludes as regards the reaction of living bone to metallic suture or pins, that "the living bone is not prevented from osteogenesis by their presence."

Hey Groves also maintains that absorbable ligatures afford no fixation in the real sense of the word, becoming softened in a few hours and yielding to any strain. With these conclusions my own experience is in entire accord.

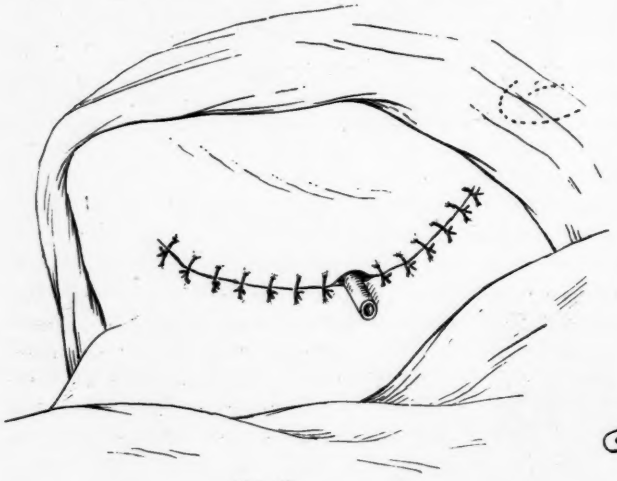


FIG. 41.

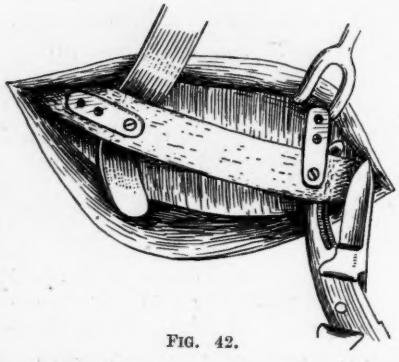


FIG. 42.

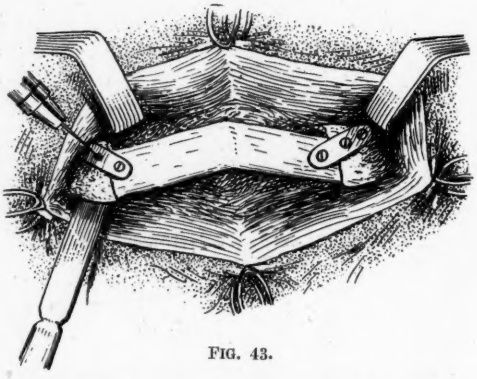


FIG. 43.

Efficient fixation there must be. If it can be attained by means other than the use of metal plates or wires, so much the better. In certain situations and under certain

conditions it is possible to fix a graft by wedging, with the assurance that such fixation will be adequately maintained. There are, however, a large number of cases in which such fixation is totally impossible. It will be shown that the success of the graft is in no wise jeopardized by the use of metal plates.

The procedure as regards the treatment of the periosteum has varied. Where tibia has been used, no attempt has been made to preserve the periosteum. On the rare occasions when a rib has been deemed more suitable, the periosteum has been retained on the outer aspect. As far as is known, no difference in behaviour has been determined by the presence or absence of this membrane.

FIG. 44.

Ten cases have been operated on by the use of free grafts in the manner described. The length of the graft has varied from $2\frac{1}{2}$ to $7\frac{1}{2}$ centimetres. In two cases suppuration occurred with subsequent extrusion of the whole graft. In both cases insecurity of fixation was the causative factor. In one case the electric motor broke down, necessitating the use of the hand drill; the splint was thereby strained to such an extent that in a few days it gave way, thus allowing free play to the previously fixed posterior fragment. Even in these cases, however, the area of the gap has been considerably diminished by the growth of a new bone. In one case wiring has been rendered practicable, as I know from direct inspection of the fragments. The other case can now be dealt with by means of a pedicled graft, owing to diminution in the size of the gap. In three of the remaining eight cases localized infection has occurred. In one the tissues overlying the graft were very badly nourished, and a sinus developed several weeks after operation. In the other two cases lobules of the parotid were wounded in exposing a very deeply placed posterior fragment; salivary fistulæ with inevitable infection occurred; in neither case has infection determined failure.

FIG. 45.

In three of these cases sufficient time has elapsed since operation—ten to twelve months—to permit a just assessment to be made of the results obtained. Of five cases, then, whose fate is known, three have been completely successful. Of the remaining five, progress has been such, as compared with known successes, that at the very minimum a percentage

success of 60 is assured. It must be emphasized that the failures occurred in the earliest cases, and are ascribable to known causes. Every case subjected to grafting has been one presenting a condition of floating non-union, and no selection whatever has been exercised.

Figs. 44, 45, 46, are characteristic *x*-ray photographs showing the condition before, during, and after treatment; the plates were removed as soon as bony continuity had been established. In *Fig.* 47 another case is illustrated; firm continuity has been established, with a perfect articulation; the patient has been discharged with plates and screws *in situ*.

FIG. 46.

Pedicled Grafts.—It is obvious that the use of free grafts is open to many forceful objections. The graft consists of a devascularized fragment; its exact mode of action is for this very reason not definitely settled, in spite of all endeavours at elucidation; for this reason, too, it is peculiarly susceptible to sepsis. The employment of bone possessing its own independent blood-supply is infinitely preferable on practical and theoretical grounds. Theoretically, because no doubts can arise as to its mode of action. Practically, because results will be more certain and more rapid. These advantages will accrue provided coincident disadvantages do not outweigh them. The pedicled graft has been employed in the case of the limbs, and occasionally to make good defects in the jaw. In the latter case, clavicle, sternum, and rib have been utilized, the pedicle being planned according to the source of the graft and the position of the defect. In addition, small fragments of the jaw itself pedicled on periosteum have been employed; it is obvious that the applicability of this procedure must be very limited, and it scarcely deserves to rank in the category of pedicled grafts. Owing to technical and other difficulties, these operations have not found favour. Hey Groves, discussing this question, says: "In general terms it may be said that these elaborate pedicle operations are obsolete. They all involve very grave disadvantages."

FIG. 47.

The appeal of the pedicled graft, however, as a sound surgical measure cannot be denied. My attention had been constantly directed to the remarkable way in which union occurred in comminuted fractures of the mandible. Particularly striking were a series of cases in which a large fragment of the basal margin was apparently completely detached. So consistent were the results, that union could confidently be predicted in such a case even when considerable loss had occurred in the overlying parts of the bone. A consideration of the anatomy of this portion of the bone (or, to be accurate, that portion lying in front of the masseter) showed that to its lower

margin was attached the deep cervical fascia, to its outer surface the platysma, to its inner surface near the symphysis the anterior belly of the digastric. It seemed clear, both on clinical and anatomical grounds, that this portion could be detached and utilized as a pedicled graft. The first operation carried out on these lines was performed in June, 1917. The feasibility of the procedure was clearly demonstrated. Other operations of this nature have followed, and improvements in technique have been evolved. Months must elapse before errors are demonstrated, and before it can be determined whether or not remedial measures have succeeded.

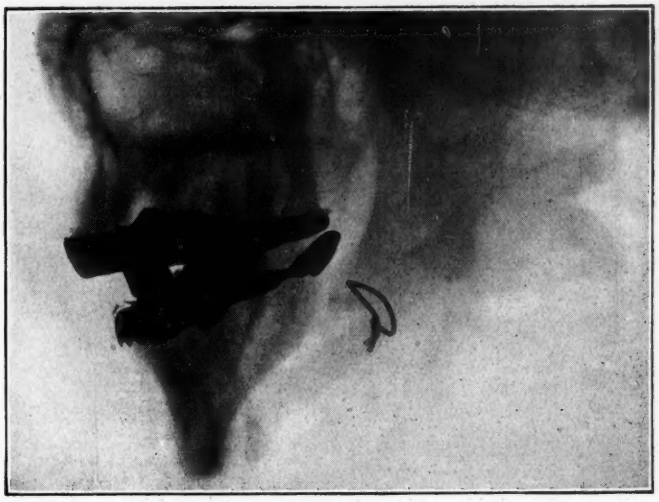


FIG. 48.

In my first cases, contact between the pedicled graft and the freshened fragments was maintained by absorbable sutures, first catgut and then kangaroo tendon. It was found that union of the graft with the posterior fragment had failed owing to the pull of the muscular pedicle. In three cases exhibiting this defect the fracture area has been again exposed. Union of the graft with the anterior fragment was so perfect as to escape detection. Posteriorly, fragment and graft were separated by fibrous tissue. The graft and fragment were refreshened and wired together (*Fig.* 48). It is obvious that a secondary operation of this nature must diminish the chances of complete success.

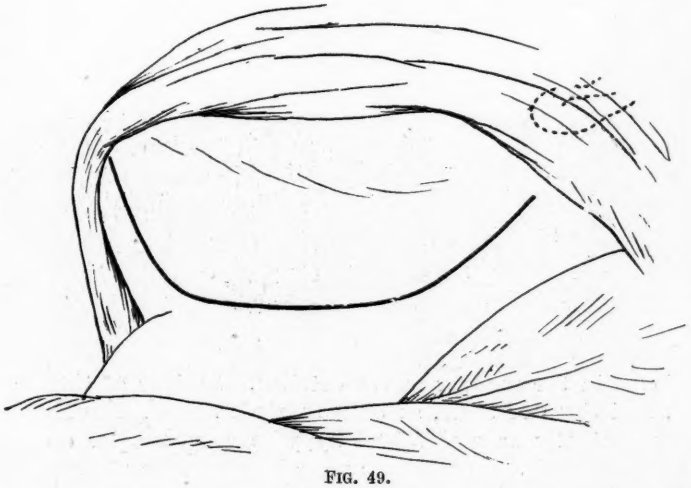


FIG. 49.

To remedy this error in technique, contact is now maintained by means of silver wire. The procedure is as follows. The skin incision is made extending well into the neck, reaching a lower level in front than behind (*Fig.* 49). A flap consisting of skin only is raised to the requisite level. The posterior fragment is thoroughly exposed. The extremity only of the anterior fragment is exposed, so that the extent of the gap may be gauged. An incision is now made through the soft parts clothing the outer aspect of the anterior fragment, at a level immediately below the buccal sulcus. The basal margin of this portion of the jaw is then sawn off (*Fig.* 50). The periosteum on the inner aspect of the fragment is incised. Lateral incisions through platysma and deep fascia are made to define the pedicle, which is then gently dissected from the underlying structures. The graft is thus freed to an extent sufficient to allow easy adaptation in its new position. The posterior fragment is now freshened to provide as broad a surface of contact as possible.

Anterior and posterior fragments are then drilled for the passage of a fine silver wire (*Fig.* 51). The wires are passed through the pedicle, surround the graft, and, when tightened and twisted, ensure snug contact between graft and freshened fragments (*Fig.* 52). The soft parts are brought together with a few catgut sutures, and the skin sewn up (*Fig.* 53). A drainage tube is inserted and retained for twenty-four hours. *Figs.* 54 and 55 illustrate a case thus dealt with. It is scarcely necessary to add that the same type of splint is utilized as for a free graft.

The employment of such a pedicled graft to remedy defects in the mandible is, so far as I am aware, an entirely novel procedure. I have succeeded in thus detaching a thick

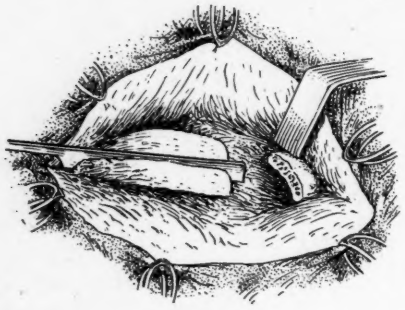


FIG. 50.

FIG. 51.

well-nourished bone fragment, measuring 3½ centimetres in length. The vast majority of ununited fractures occur on the lateral aspect of the mandible, and rarely exhibit a gap exceeding 3 centimetres in length. This operation, then, enjoys a wide range of applicability, and constitutes, I submit, a considerable addition to the methods of treatment at our disposal. I have not as yet employed bilateral pedicled fragments as a means of remedying non-union at the symphysis, but shall certainly do so when occasion arises. Free grafts are now used only in cases where the gap is too wide to be bridged by a pedicled graft.

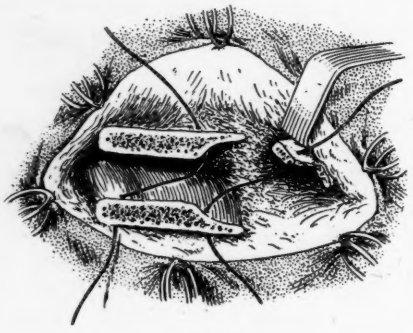


FIG. 52.

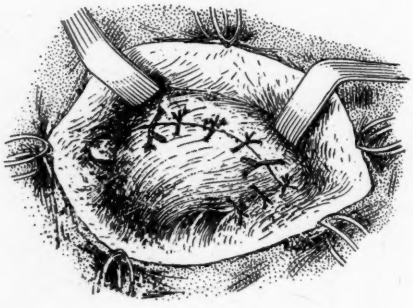


FIG. 53.

Eight cases have been dealt with in the manner above detailed. In four of these absorbable sutures were employed, and three of these, as before stated, needed a second operation. In the last four cases contact was maintained by wire sutures. In one only has there been the slightest trace of sepsis. In this case some latent source of sepsis must have been encountered inadvertently. Considerable swelling occurred, with discharge of blood-stained pus into the mouth, soon followed by the subsidence of all symptoms. The wound in the neck was not affected.

The results obtained by this method are rapid and certain. To such an extent is this so, that in cases with non-union amenable to treatment by means of a pedicled graft success can be practically guaranteed. The first case of the series is not claimed as a complete success, but the causes of failure, as before noted, have been recognized and remedied.

The results obtained by the operative treatment of non-union may be concisely summarized thus. There were 30 cases* subjected to operation; in 2 of these the operation was abandoned as impracticable. Of the remaining 28 cases, 10 have been operated on too recently to permit of any definite statement as to the results obtained. Of the 18 cases whose fate is known, 13 have been completely successful, 2 considerably improved, while the other 3 must be regarded as failures. It will thus be seen that the successes are over 70 per cent.

There has been no mortality, and post-anæsthetic complications have been entirely absent. In all but two cases ether has been administered by intratracheal insufflation, and the uneventful convalescence is entirely attributable to the skill exhibited in administration by Dr. Francis Shipway and Mr. Ramsey Phillips.

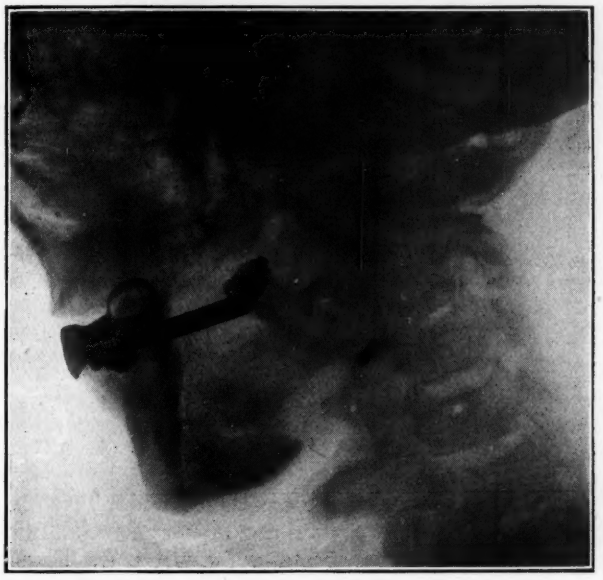


FIG. 54.

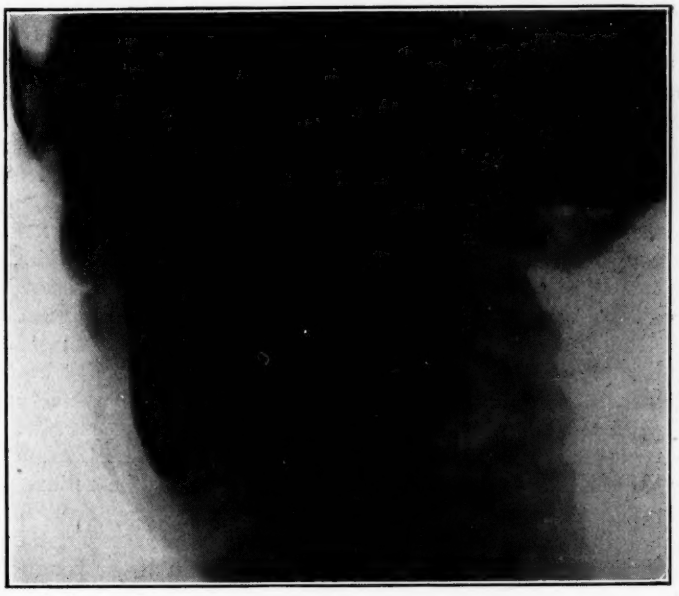


FIG. 55.

The results are such, in a word, as to justify the conclusion that no patient so afflicted should be discharged until operation has not only been offered to but urged upon him. The functional disability associated with ununited fracture of the mandible is an unnecessary disability in most cases. It is a blot upon the escutcheon of surgery which we, if we be worthy devotees of the art, must determine to remove.

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THE TREATMENT OF GUNSHOT WOUNDS OF THE FACE ACCOMPANIED BY EXTENSIVE DESTRUCTION OF THE LOWER LIP AND MANDIBLE.

By Major V. H. KAZANJIAN, Harvard Surgical Unit,
and Captain HAROLD BURROWS, R.A.M.C. (T.F.)*

Many problems arise in the treatment of gunshot wounds of the jaws. Not the least perplexing of these confronts the surgeon in a case in which the greater part of the body of the mandible has perished together with the lower lip, chin, and sublingual tissues (see *Figs.* 59, 66, 73). Such cases are not frequent; nevertheless it may be worth while to consider the means by which the victim of such an accident may yet be rendered an efficient individual.

We may describe the treatment under three headings, which approximately represent three successive stages in the management of any case: (1) *Early treatment*; (2) *Re-establishment of the mandibular function*; (3) *Restoration of the lower lip and chin.*

1. **Early Treatment.**—Our first care will be concerned almost entirely with preserving the patient's life, and meeting the various early complications which may arise. Shock calls for no special comment; it is treated as in other major wounds. Primary hæmorrhage is not in itself a great menace in these cases, for the vessels injured are terminal and not of large size, while the wound is widely open from the first. Secondary hæmorrhage is uncommon for similar reasons; when it does come about it is not profuse, and is easily checked by securing the bleeding vessel in the open wound. Local sepsis, though it may be severe in the early stages, as a rule subsides rapidly with suitable attention. Sustained pyrexia is rare, unless secondary complications have developed in the lung or other organs.

Certain special dangers, peculiar to the cases, are met with, and they call for remark. The first of these is respiratory obstruction. Two factors are involved in its production. The first and less important is traumatic œdema of the tongue and glottis. The second, and principal one, is the absence of the body of the mandible, for this entails the loss both of the anterior attachments of the tongue and of the elevators of the larynx; the consequence is that, if the patient be supine, the tongue falls back, the larynx is tilted backward, and the glottis becomes obstructed. The immediate treatment is to raise the patient into a sitting posture with the head well forward, and this simple manœuvre will often be sufficient to bring about instant relief. If it fails, tracheotomy must be done without delay. This respiratory difficulty, and the means by which it may be relieved, must be borne in mind throughout, for if a general anæsthetic be given to the patient for any purpose acute dyspnœa is almost sure to result. In such an event time must not be wasted in fruitless attempts to provide a sufficient air-way by pulling forward the tongue, for this by itself will fail. The postural treatment must be adopted at once, and if it does not succeed immediate tracheotomy must be done.

Another peril to the patient with an infected wound of the mouth is the inhalation of septic material into the air-passages, with consequent bronchopneumonia. This complication has a heavy mortality rate, and in our experience it is almost always attributable to the administration of a general anæsthetic. For this reason, and also on account

* We desire to express our indebtedness to our colleague, Captain F. Brigham, R.A.M.C., of the Harvard Surgical Unit, for kind assistance in preparing this paper.

of the liability to respiratory obstruction which has been mentioned already, we think it should be a rule never to give a general anæsthetic to one of these patients unless the nature of the case renders it imperative; in such a case, precautions must be taken to forestall the inhalation of septic discharges. Briefly stated, the precautions we employ are the reduction of salivation by means of atropine given hypodermically, administration of the anæsthetic by nasal tubes, and thorough packing of the buccal cavity with dry gauze.

Apart from urgent complications, the amount of surgical interference required in the early stages will be small, and will be limited to the removal of dirt, loose fragments of bone, teeth, and roots. A little later, when the wound begins to show healthy granulations, a certain amount of early secondary suturing may be done. This will be effected under local anæsthesia, and will be limited to sewing up the outlying radiations of the wound, and closing as much of the main wound as may be done without impeding drainage.

With regard to dressings, there is not much to be said. The wound is widely open, and is continually washed with abundance of the patient's own saliva. This necessitates frequent changes of dressing, and on each of these occasions the mouth is syringed out with antiseptic solution, usually Listerine or a solution of potassium permanganate.

The feeding of these patients calls for a few words. Owing to the loss of the anterior attachments of the tongue, as well as to the absence of the lower lip, the patient is unable to swallow in the usual way. Food must therefore be given with a nasal tube, and it must be administered in large amounts. When nasal feeding is impossible on account of obstruction of the nares, a small-calibre soft œsophageal tube is necessary. It is desirable, however, to use the nasal tube whenever this is possible, for its introduction is less unpleasant for the patient, while it avoids thrusting septic discharges from the mouth into the fauces.

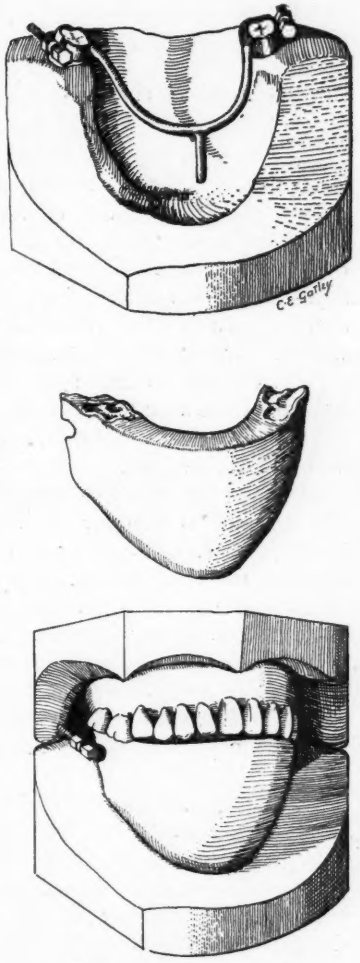

FIG. 56.—Bands and T-splint.

2. Restoration of Mandibular Function.—Two distinct procedures are required in order to restore to the patient some power of mastication. In the first place we must ensure at an early stage that the portions of the lower jaw which have survived shall remain in a position which will enable them to perform useful work; for upon these remnants, and resting upon them alone for support during mastication, will lie the artificial jaw. They may include a portion of the body of the mandible, or they may consist only of the two ascending rami, which, when displaced somewhat inward, forward, and upward, may yet be capable of supporting a prosthetic appliance which rests upon what is anatomically their anterior surfaces; and the degree of their usefulness will be proportional to the amount of pressure they can support. Unless these bony platforms are carefully conserved, irremediable displacements will ensue, and the mandibular function will be lost permanently and entirely. The second process to be described consists in the provision of an artificial substitute for the missing portion of the jaw. We shall consider these two subjects in detail.

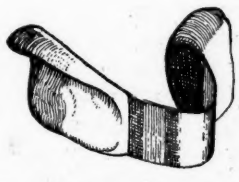

FIG. 57.—Temporary splint for edentulous cases.

Prevention of Bony Deformity.—The attitude which the surviving fragments of the mandible will assume, if the case be neglected, will vary according to the position of the fractures. If the jaw has been broken at the angle, the proximal fragment will be drawn upward and outward, and, assuming that it is not restrained, will become lost ultimately in the tissues of the cheek. When, however, the fracture is further forward—in the bicuspid region, for example—the chief displacement will be inward, toward the mid-line of the mouth, with displacement upward in addition.

As soon as the local conditions are sufficiently favourable, temporary splints are adjusted which will hold the remaining portions of the mandible in a proper position—that is to say, directly under the alveolar ridges of the upper jaw, and separated from them by a sufficient intermaxillary space. This position is slightly inwards from the normal position of the intact mandible, the alveolar ridges of which are more widely separated than those of the upper jaw; and the reasons for displacing the fragments inward when the body of the mandible is lost, is that they will then act with the best mechanical advantage, and give greater stability and efficiency to the artificial jaw; moreover, a smaller prosthetic appliance will suffice, while the gap in the soft tissues will be diminished and consequently easier to close.

Two types of temporary splints are made, the selection being in accordance with the nature of the case: (1) If there are teeth existing on both sides of the jaw—for example, the third molars—metal bands are fastened to them, and these bands are connected by a heavy arch (German silver 12 A.G.) which carries a T-piece in the middle; this arch holds the two parts of the jaw in proper position. A removable vulcanite splint (*Fig.* 56) is made to fit over the arch. (2) If no teeth are available for giving attachment to these splints, a metal plate (German silver 24 A.G). of suitable size is bent into shape. To the ends of the plate moulding composition is added, and the impression of the alveolar ridges is taken with properly occluded surfaces. The plate is removed from the mouth, and after trimming off the surplus composition the model is reproduced in vulcanite rubber. This makes a simple and efficient splint, and the slight springiness at the middle facilitates adjustment (*Fig.* 57).

Practically no alterations are made until the wound is ready for plastic operation. The characteristic shape assumed at this stage by the soft tissues is seen in *Fig.* 69, p. 81.

During this stage it is important to ensure that there shall remain a buccal furrow between the cheek and the remaining portions of the alveolus of the lower jaw. For if this groove has been obliterated it is difficult to secure proper function and stability of the prosthetic appliance. To avoid this drawback, suitable flange-like extensions are incorporated with the temporary splint which prevent the disappearance of the furrow during the process of scarring. It may happen, however, that the alveolus has been in large part destroyed, or that for some other reason the buccal groove has disappeared before the temporary splint is applied. In such a case the mucous membrane is incised along its attachment to the alveolar ridge, and a cut is made deeply into the underlying soft tissues along the margin of the jaw; mattress sutures are inserted into the cut margin of the mucous membrane, and then passed through the bottom of the groove, emerging on the skin surface, where they are tied over buttons. In this manner a satisfactory buccal furrow may be re-established and maintained by the temporary splints.

3. Restoration of the Lower Lip.—Before proceeding to close the wound, an artificial jaw is made of vulcanite, and the patient wears this for a while in order to get accustomed to it before the plastic operation is carried out on the soft parts. The appliance has the following features: (1) It is held in place by the remaining teeth, if any are available—or, in the absence of teeth, by the alveolar ridges of the lower jaw—and by the occlusion of the upper teeth. (2) It has sufficient bulk to replace the missing bony tissue, especial attention being given to the prominence of the symphysis. (3) It is made in three sections, to facilitate removal, cleaning, and readjustment in the mouth. After the plastic operations have been completed and the soft tissues have assumed their final form, a new appliance is made as a permanent denture.

With regard to the plastic operations on the soft parts, we aim at enabling the patient to retain his saliva, to hold food in his mouth during mastication, to drink from a cup, to articulate so as to be understood, and to have a passably good appearance. To achieve these objects we must close the wound, provide it with a complete epithelial lining on its buccal surface, and restore a red lip margin.

In closing the wound we are at once faced with a difficulty, for skin-covered tissue is not available in great quantity, and yet we have to provide tissue not only to close the gap, but to cover the artificial appliance and restore the profile of the chin. The flaps used are taken from the cheeks and the sides of the neck, as shown in the illustrations. These flaps are found occasionally to have but little extensibility, owing to the presence in them of strands of scar tissue. However, they can be brought together over the artificial chin as a rule. If, after they have been sutured, there is so much tension that they remain white and bloodless, the tension may be sufficiently relieved by making small, shallow, criss-cross incisions into them with a scalpel.

The provision of a complete epithelial lining for the buccal surface may be a matter of difficulty, for although the mucous membrane of the cheek and lips is very extensible, yet there is very little of it which is available in these cases. What there is will be sufficient perhaps only to line the upper part of the lip. To provide a lining for the deep pouch in which the artificial chin has to lie, we turn up a flap of skin from the front of the neck. The fact that this is derived from a hair-bearing area does not appear to matter. For a time hairs continue to grow in the mouth, but this does not trouble the patient, and it seems that after a while spontaneous epilation takes place. Possibly the glandular structures of the skin atrophy also. At any rate, the lining, after a while appears to the naked eye almost like normal buccal mucous membrane.

With regard to the pink lip margin, the difficulty of restoring this is not so great as might have been expected. Usually some portion of the lower lip has survived, and this can often be used; for the lips can be stretched to a remarkable extent, and half a lip, detached except at one end, can be made available for the whole width of the mouth.

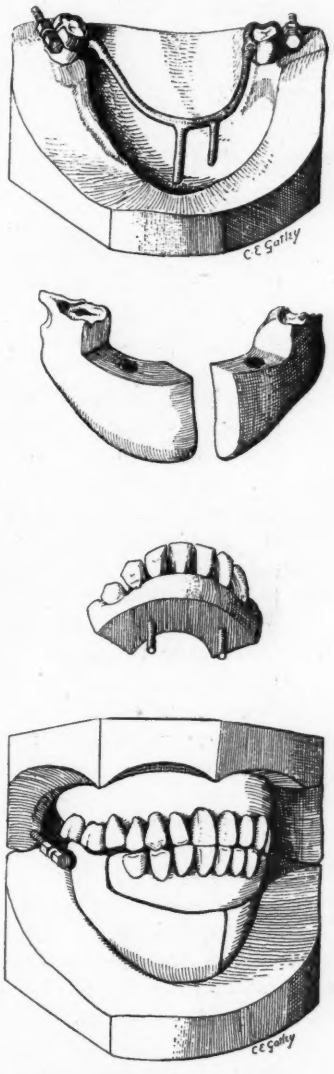

FIG. 58.—*Case* 1. Operation splints.

DETAILS OF CASES.

Case 1.—Pte. A. G. E. Wounded Aug. 4, 1916. Admitted Aug. 7. The wound is extensive, the lower lip is lacerated, the soft tissues of chin and sublingual region have been carried away, and the entire body of the mandible anterior to third molars on each side is missing. Upper jaw edentulous. Wound inflamed. Tongue swollen. Tracheotomy has been performed at C.C.S. (*Fig.* 59.)

Aug. 28.—A minor operation was performed, and a few pieces of loose bone removed. A little later patient fitted with temporary splint. As soon as wound was sufficiently clean, the following appliance was made preparatory to plastic on the soft parts. Bands were fastened on the third molars, and to these bands was fixed an arch which carried two perpendicular wires. To this arch a removable vulcanite plate, made

in three pieces, was adjusted (*Fig.* 58). The plate had sufficient bulk to fill gap in mandible and to provide a foundation with a mental prominence to support the soft tissues which were to reconstitute the lower lip and chin (*Fig.* 60).

Jan. 1, 1917.—Plastic operation performed under general anæsthetic. Anæsthetic given through a nasal tube, mouth being packed with gauze. The mucous membrane was divided along floor of buccal groove on each side as far back as the third molar, and from the hind end of each of these incisions a vertical incision was carried up on buccal surface of cheek. Superficial flaps were then made as shown in *Fig.* 61. The lower angles of these flaps consisted of skin and subcutaneous tissue only, but when the level of the buccal groove was reached, incision was carried through into the mouth and continued backward along buccal groove as far as anterior border of the masseter; behind this the flaps once more consisted only of skin and subcutaneous tissue. As soon as these flaps had been freed and bleeding arrested, temporary appliance already described was inserted, the two halves of lip were sutured, and mucous membrane was united with

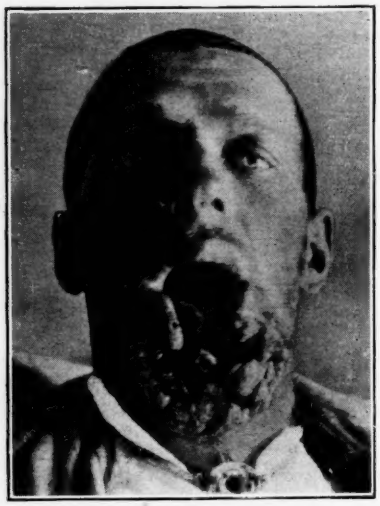

FIG. 59.—*Case* 1. First photograph.

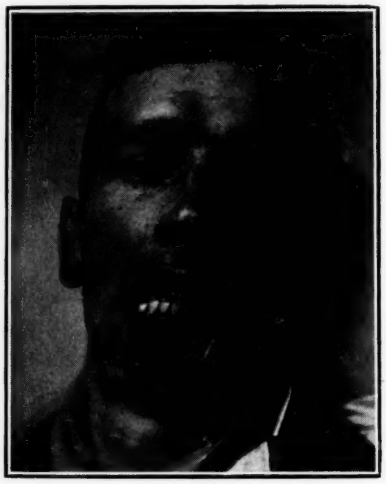

Fig. 60.—*Case* 1. Appliance fitted preparatory to plastic operation.

catgut sutures from above downward. The cheek flaps were now rotated forward and united along the mid-line. When this had been done there remained a large raw surface, triangular in shape, on each cheek. These were diminished in size, though not completely closed, by a few sutures.

At the end of this operation there was an area uncovered with epithelium on inner surface of chin, as the mucous membrane was not available in sufficient quantity to cover the mental prominence of the artificial jaw. As a result a chronic ulcer remained, and by its contraction caused depression of the lower lip. The condition resulting after this operation is shown in *Fig.* 62.

May 15.—Second operation under local anæsthetic. The ulcer in mouth was excised together with the overlying scar. Mucous lining of mouth completed by flaps of mucous membrane. Flaps of skin and subcutaneous tissue were then made as shown in *Fig.* 62, and sutured together in the mid-line. This raised the lower lip and placed it in contact with the upper.

May 21.—A support was applied in order to prevent the retraction of the lip during healing of the wound.

July 14.—The patient supplied with permanent plates of the following kind: (1) An ordinary upper plate with an inclined plane surface at the region of tuberosities; (2) A

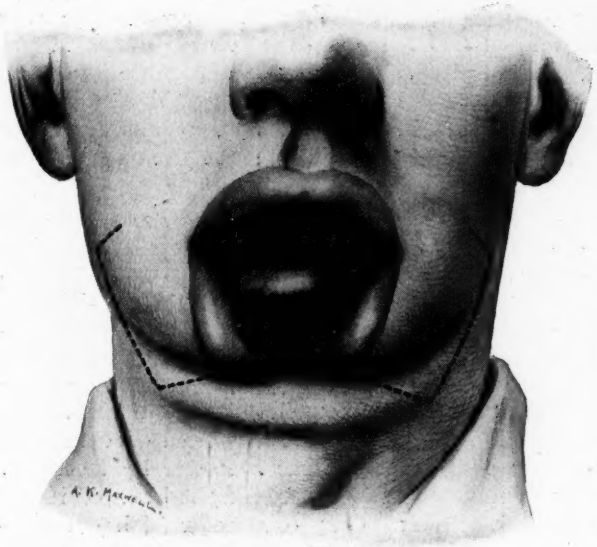

FIG. 61.—*Case* 1. Diagram of first plastic operation.

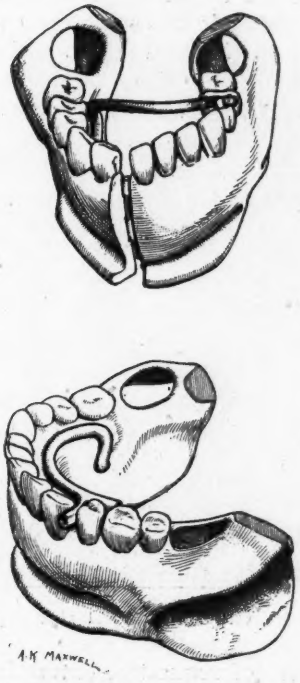

FIG. 63.—*Case* 1. Permanent dentures.

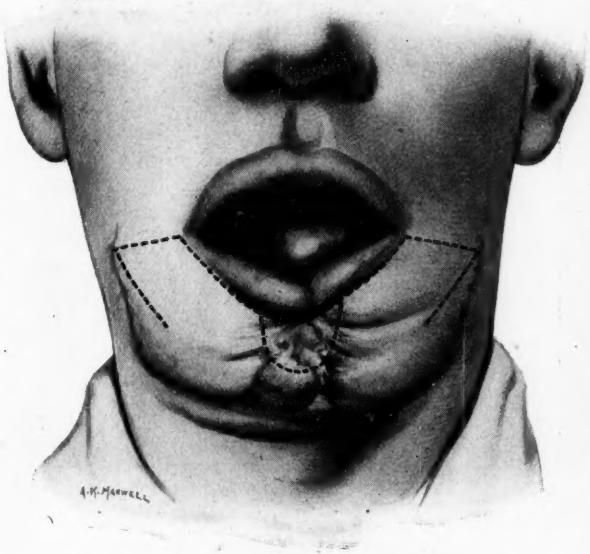

FIG. 62.—*Case* 1. Diagram of second plastic operation.

FIG. 64.—*Case* 1. Photograph of final cast.

lower plate made with hinge in the middle (*Fig.* 63) which allowed the two halves to fold together to facilitate introduction into the mouth; this hinge can be locked, when the appliance is in position, by means of a bar along lingual aspect of plate; this denture also has inclined planes at back, which correspond with and meet those of upper plate; the purpose of these is to force lower plate into position and to keep it there during mastication; on the anterior surface of the apparatus is a deep furrow with ridge below corresponding to mental prominence; this has caused a corresponding groove in the soft tissues, and also served to support the lower lip.

FIG. 65.—*Case* 1. Final photograph.

Patient's final condition is shown in *Figs.* 64, 65. He has a good profile and a fair front view. He can drink normally, hold his saliva, speak plainly, and masticate soft food—for example, chicken, potatoes, and bread—and does not appear to find the artificial jaw troublesome.

Case 2.—F. N. Wounded Aug. 21, 1916. Admitted Aug. 23. A large shell wound of chin with extensive loss of soft tissues. Lower lip lacerated. Body of mandible missing from right bicuspid region to left third molar. Only one molar (right) remaining in lower jaw (*Figs.* 66, 67, 68). Various minor operations were performed under novocain, for removal of sequestra, extraction of roots from upper jaw, and partial suturing of borders of wound. Temporary retention splints applied.

Feb. 2, 1917.—An appliance made for patient to wear preparatory to plastic operation on the soft tissues, composed of hinged plate of suitable size and bulk which rested upon

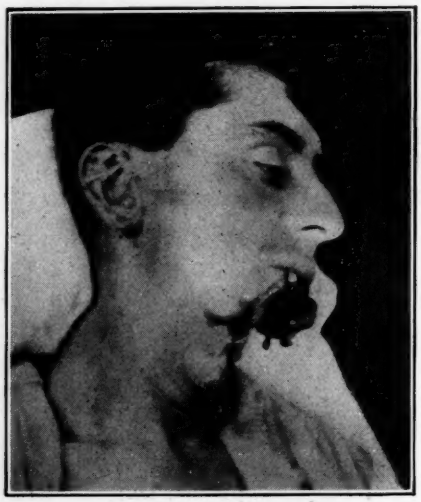

FIG. 66.—*Case* 2. First photograph.

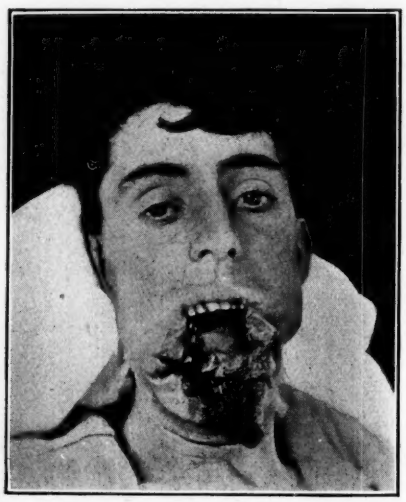

FIG. 67.—*Case* 2. First photograph.

remaining portions of alveolar ridges of lower jaw, the occluding surfaces in molar regions receiving the cusps of upper teeth which helped to retain plate in position, while a second plate interlocked and held apparatus together.

Feb. 13.—Plastic closure of wound under novocain. Cheek flaps formed as in previous case (*Fig.* 71), and the lip edges and mucous membrane joined until the

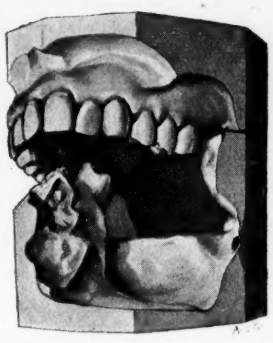

FIG. 68.—*Case* 2. Cast (inside) taken shortly after injury.

FIG. 69.—*Case* 2. Second photograph.

FIG. 70.—*Case* 2. Photograph of final cast.

tension forbade further suturing. This left a gap through which artificial chin (not shown in the illustration) projected. Gap was closed by turning up a triangular flap

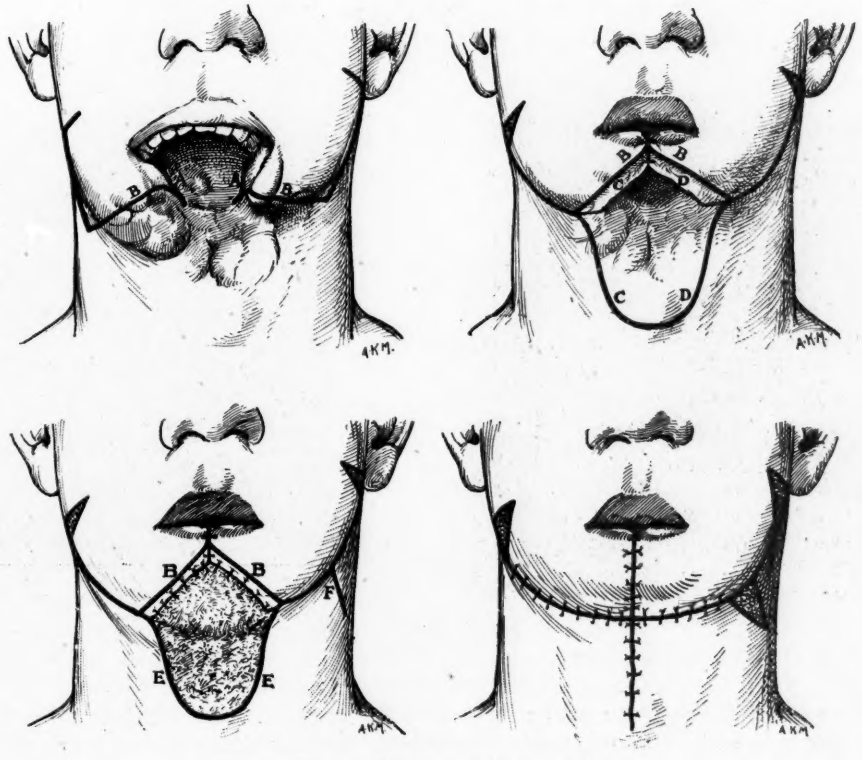

FIG. 71.—*Case* 2. Diagrams of plastic operations.

of skin from the neck and suturing this to edges of mucous membrane, epithelial surface facing inward so that it lay in contact with vulcanite appliance. The cheek flaps were now brought together over this and united along the median line, and the raw surface on anterior surface of neck was closed by drawing together the skin of neck, which is plentiful in this region. Tension of cheek flaps when they were stretched over the artificial mental prominence rendered them white and bloodless. This tension was sufficiently relieved by criss-cross incisions.

FIG. 72.—*Case* 2. Final photograph.

After wound had firmly healed, the patient was supplied with a permanent appliance similar to that used in the former case. The final condition of patient is shown in the photograph (*Figs.* 70, 72). The result was satisfactory both as regards function and appearance.

Case 3.—F. S. Wounded July 6, 1916. Admitted July 8. Extensive shell wound of chin. Great loss of soft tissue, including greater part of lower lip and chin. Mandible missing from angle on right side to second molar on left. The second and third molars present. Tongue much swollen. A small portion of shell was removed from right side of neck, 1½ in. below the ear, under novocain. (*Figs.* 73, 74.)

Temporary splints adjusted at an early stage and retained until shortly before closure of wound. Preparatory to the main plastic operation an appliance was made resembling that made for *Case* 2, but a removable condyle guide was adjusted on right side,

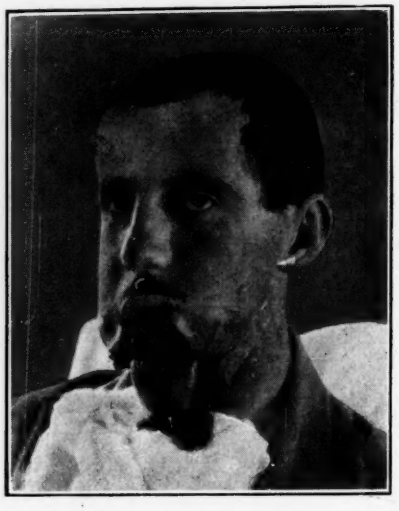

FIG. 73.—*Case* 3. First photograph.

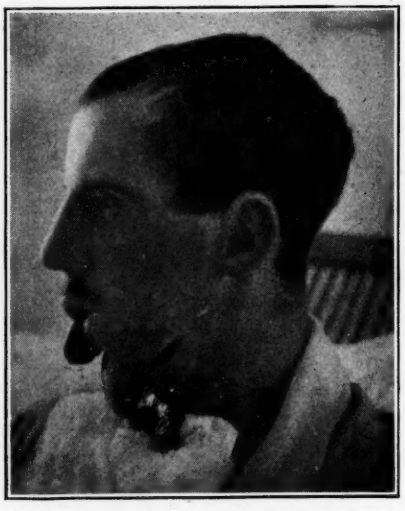

FIG. 74.—*Case* 3. First photograph.

as there was no bony tissue on that side to give support to artificial jaw. This guide consisted of a movable bar attached to third upper molar and passing down along lingual aspect of lower plate, while in front of bar was a hooked wire attached to the plate; during mastication this wire glided over the bar and prevented the plate from being pushed backward.

July 28, 1917.—Plastic operation under novocain. The details of this operation and flaps used were similar to those in *Case* 2, and no separate description is necessary (see *Fig.* 71). The permanent prosthetic appliance was similar, too, to that used for *Cases* 1 and 2, except for the addition of the condyle guide. The final condition of patient is shown in *Figs.* 76, 77.

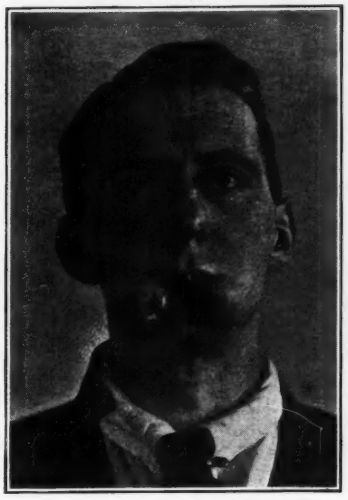

FIG. 75.—*Case* 3. Second photograph.

Case 4.—A. P. Wounded Dec. 23, 1916. Admitted Dec. 26. Extensive shell wound causing laceration of soft tissues and fracture of mandible. From right cuspid to left angle the lower jaw is entirely missing (*Fig.* 78).

April 1, 1917.—Patient having been fitted with artificial jaw of vulcanite, a plastic operation was performed under novocain. Cheek flaps were made, and a symmetrical triangular flap was turned up from neck to complete floor of mouth. A great difficulty was experienced because the left cheek flap consisted mainly of bulky scar tissue which was inextensible and was rotated into position with difficulty, and when sutured into place much puckering of the face resulted, while there remained a large triangular raw surface on the left cheek which it was not possible to cover.

May 16.—Second plastic operation to cover raw surface on left cheek.

Aug. 15.—Patient has large scar on left side of face, left corner of mouth is protuberant owing to thick scar tissue underlying the skin. Salivary fistula

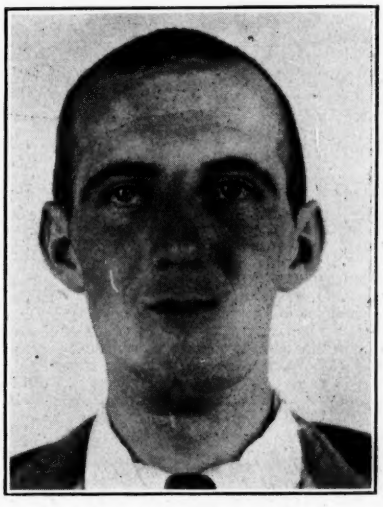

Fig. 76.—*Case* 3. Final photograph.

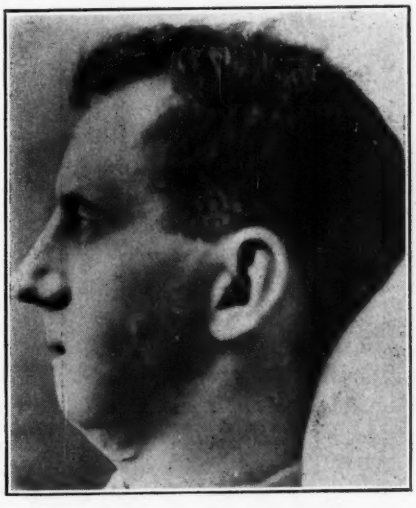

FIG. 77.—*Case* 3. Final photograph.

remains in left side of neck. Patient cannot open the mouth well. Is having massage of the face.

Nov. 9.—Trismus has disappeared and scar tissue become much more supple. Operation: salivary fistula closed; left corner of mouth improved by removal of triangular piece of skin together with mass of underlying scar tissue.

Jan. 18, 1918.—Fourth plastic operation in order to remedy depression of the lower

lip. Permanent prosthetic appliances made consisting of upper and lower vulcanite plates. Lower plate retained by two clasps round right bicuspids and horizontal spring attachment on left which acts as a condyle guide (*Fig.* 80).

The final result is shown in *Fig.* 79.

FIG. 78.—*Case* 4. First photograph.

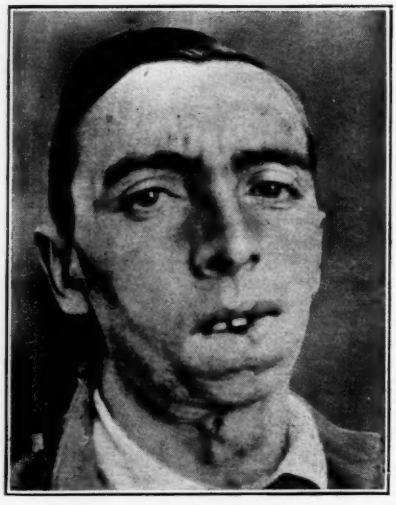

FIG. 79.—*Case* 4. Final photograph.

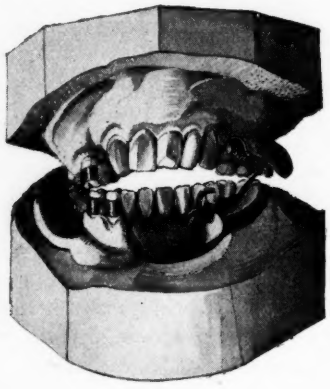

FIG. 80.—*Case* 4. Permanent dentures. Horizontal spring and lever. To the upper denture is attached a bar about one inch in length, designed to carry a button at each end. (Where there is sufficient vulcanite the buttons are attached directly to the denture.) A lever is constructed with the posterior button as a fulcrum. Its long arm travels in a groove on the buccal aspect of the lower denture, while a spiral spring acts between the end of the short arm and the anterior button. A small extension at the end of the long arm has contact with a pin which originates in the lower denture. By its action the device as a whole serves to keep the dentures in position, and also prevents the lower denture and remaining portion of the mandible from rotating to the left. It does not interfere with either incisal or lateral movements in mastication.

CONCLUSIONS.

Fortunately such extensive destruction of tissues as occurred in these cases is not often seen. In the main we have followed the same line of treatment in all. The principal points to be observed are :—

1. The preservation of the surviving portions of the mandible in the desired position.
2. The substitution of lost bony tissue by vulcanite appliances before the performance of plastic operations on the soft parts.
3. Postponement of the main plastic operation until suppuration has ceased and the patient is in a good physical condition.
4. The use of a similar scheme of flaps in all the cases.

As seen in the photographs, a reasonable fullness of the chin was provided, and the general result, though far from perfect, is not repellant to the eye. The speech of the patients is fair and intelligible, and undoubtedly will continue to improve. The artificial plates are simple and removable, and have good stability without the aid of additional springs—though to this the fourth case is an exception, for here it was necessary to employ a spring to control the left side.

As to the efficiency of the jaw to masticate food, we may state that a good part of this function has been restored. Normally the human jaw can exert about two hundred and fifty pounds of pressure, while the force required for mastication of ordinary food reaches to fifty-five pounds. When part of the mandible has been lost, the potency of the remainder will be proportional to the amount of bone remaining that can support artificial dentures. This being so, it might be thought that mastication would be done only by the posterior parts of the plates where they rest upon firm surfaces, and that the anterior part of the artificial jaw, resting as it does on soft tissues alone, would be unable to participate in the function. To some extent this is true. Yet it is possible, by means of inclined planes upon the posterior ends of the plates, to project some portion of the biting force to the artificial incisors. A simple plan may be used to enable the patient to chew with greater force and satisfaction, namely, by teaching him to press up the chin with the left thumb during each act of mastication. With practice and perseverence the habit becomes acquired, and, while being helpful, it is not unsightly.

An ideal restoration of a lost mandible would involve re-establishment of bony continuity by grafting. We hope that means will be found to achieve more perfect results by such a method. This is a problem that awaits solution in the future. At the present time it is satisfactory to know that an artificial jaw can be both a useful and a practical substitute for one that has been lost.

NOTES ON THE PRINCIPLES AND RESULTS OF TREATMENT IN 200 CASES OF INJURIES TO THE FACE AND JAWS.

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It has been truly said that "the excellence of every art depends upon the complete accomplishment of its purpose," and it is the intention of this communication to classify and systematize the results obtained in two hundred cases of face and jaw injuries treated in a special department of a general hospital. These cases belong to a series, and have not been specially selected, so that our results may not be suspected of partiality.

Much has been written hitherto by British, colonial, and foreign authors describing principles of treatment, specifying types of splints and apparatus employed, outlining the procedure in dealing with cases seen early and late, devising nomenclature, etc.—all essential in an exhaustive treatise on jaw surgery and jaw orthopædics. Little, however, has been published giving results of treatment, tabulating the duration of stay in hospital, destination of the patient, whether returned to duty, etc. The present contribution essays to meet this need, and we trust it may stimulate the publication of others from the various special centres where the treatment of jaw and face injuries is undertaken.

In our series of 200 cases, 145 were admitted with definite injury to bone; the remaining 55 were suffering from injuries to the soft parts only, giving rise to various disabilities.

INJURIES TO BONE.

Table 1.—Showing the Number and Percentage of Mandibular and Maxillary Fractures (exclusive of Alveolar Fractures), and of Alveolar Fractures.

Part Fractured	Number	Percentage
Mandibular fractures:—		
(*a*) United on admission	15	10·4
(*b*) Incomplete	9	6·2
(*c*) Complete	95	65·5
	—119	
Maxillary fractures	8	5·5
Alveolar fractures	18	12·4
Total	145	100·0

Fractures of the Mandible.—

a. United on Admission.—This class consists of 15 cases, all of which required prosthetic treatment, many of them surgical or other treatment in addition—such as attention to sinuses, and extractions—similar to that frequently necessary in complete fractures.

b. Incomplete Fractures.—There were 9 of these cases, in 8 of which there was a crack either at the angle or in the body of the jaw, while in the ninth a small fragment was detached from the anterior border of the ascending ramus.

c. Complete Fractures.—This class consists of 95 cases, which are classified in *Table* 2 according to the region in which they occur.

Table 2.—Classified List of Complete Mandibular Fractures.

Site of Fracture	Number	Percentage
Mesial or incisor region	26	27·4
Canine, premolar, or molar region	32	33·7
Angle	21	22·1
Ascending ramus, including condyle and coronoid	10	10·5
Multiple	6	6·3
Total	95	100·0

It is often difficult to locate fractures definitely to any one region, so that the above classification has been adopted merely for convenience, and is more or less arbitrary.

The amount of comminution present depends upon the nature and velocity of the projectile, the angle at which the blow is received, and the distance which the missile has travelled before impact. In the majority of gunshot wounds there is considerable comminution, while in 'civil' fractures (due to kicks, blows, or falls)—of which there are 14 in this series—there is, on the other hand, little or no comminution.

Fractures of the Maxilla.—Excluding alveolar fractures, there are only 8 cases in this class. Of these, 7 were injuries to the hard palate, varying in extent, opening into the nasal cavities or maxillary sinuses. The eighth was a horizontal fracture above the palatine vault.

Fractures of the Alveolus.—This class consists of 18 cases. They were met with in one or both jaws, and varied considerably in extent. They are associated with fracture of the teeth.

FALSE TRISMUS OR LIMITATION OF MOUTH OPENING.

This clinical condition has been met with in 66 out of the whole series of 200 cases: in 25 of these it was definitely associated with fracture of the mandible; in the remaining 41, fracture either had been definitely excluded by *x*-ray examination or was very doubtful.

In all cases of definite fracture the site of the injury has been either in the ascending ramus or angle, and in such it is obvious that the muscles of mastication have been involved. Where fracture is absent or doubtful, the injury has been of such nature as to involve some fibres of the masseter, temporal, or pterygoid muscles.

The condition in many of the cases is largely due to slight spasm of the muscular tissue resulting from injury, and is easily and rapidly overcome without recurrence. In other cases it results from the presence of scar tissue limiting movement. These are more obstinate, especially where the temporal muscle is affected, and recurrence is more probable. In a third class—the most obstinate of all—the condition is due to functional spasm of all the muscles attached to the mandible.

UNCOMPLICATED INJURIES TO SOFT PARTS.

There were 14 cases suffering from slight disability due to the presence of a foreign body or pain in the scar during mastication. They require no further comment.

PRINCIPLES OF TREATMENT.

A brief résumé of the treatment—as far as it could be ascertained—which had been carried out previous to admission to this hospital may be of interest. In the majority

of cases the only earlier treatment had been directed to the soft parts, and the bony injury had been neglected. In a few cases wounds had been sutured and foreign bodies removed. The following arteries had been ligatured for secondary hæmorrhage: external carotid once; facial twice; lingual and temporal once each. Tracheotomy and laryngotomy had each been done once. Splints had been applied to one or both jaws in 19 cases. In the majority of these the mouth was in a very septic condition and the splints had to be removed almost immediately. Obviously many teeth had been retained which were not only useless but detrimental to recovery.

Early routine treatment is directed to the control and elimination of sepsis, the care of external wounds, and maintenance of the patient's health. Patients are instructed in oral hygiene, whilst constant lavage is carried out by the nursing staff. The patient's diet is arranged according to his ability to deal with certain types of foods, and follows fairly closely, with certain modifications, the scheme advanced by Captain Holt, at one time medical officer in charge of Croydon Jaw Hospital.

The study of radiographs always precedes any decision upon the necessary subsequent treatment; these radiographs are taken from as many aspects as are considered advisable. As a result a definite line of treatment is suggested, and the preliminary stage consists in the removal of teeth, or roots of teeth, involved in the area of fracture, except in those cases where retention is temporarily considered advisable from the point of view of controlling fragments otherwise devoid of efficient anchorage. In some cases a cast cap-splint is loosely adjusted within twenty-four hours of the removal of such teeth, so that displacement may be effectually controlled, and such a splint is not cemented in place until any sepsis which may be present is well under control.

In the vast majority of gunshot wounds of the face and jaws, comminution of bone and loss of tissue results, together with certain types of resultant displacement of the fragments, and often facial asymmetry. The re-establishment of a normal occlusion and orientation of the dental arch is never sought at the expense of bony union. In those cases in which comminution and tissue loss are absent (in some gunshot fractures, but especially in fractures of a 'civil' nature, the restoration of the normal occlusion is perfectly compatible with bony union; while in cases where tissue loss is very extensive (often above 4 cm.), any idea of ultimate bony union is generally impracticable, and the normal occlusion is restored so far as it is possible to do so, the future of the case depending upon the efficacy of 'bone-grafting operations.'

The essential importance of retaining (especially in the more extensive fractures) all pieces of bone which have adhered to the periosteum must be insisted upon, as such vital foci are eminently necessary in the process of ossification, acting as grafts in the process of repair, whilst their removal lessens the incidence of osseous and tends to promote fibrous union. More than one case which has resulted in fibrous union can be definitely traced to the removal of such bone fragments. This, of course, cannot be said to apply to alveolar bone, which exerts no influence on the reparative process. Neither granulation tissue, nor the subsequent callus, is laid down beyond a limited distance from the mother tissue, and reparative callus cannot bridge across definite gaps, so that the presence of such foci of ossification is very essential.

Bony union once obtained, the correction of any abnormal occlusion is proceeded with. In many cases, all that is necessary is the adaptation of a prosthetic appliance owing to the man's poor natural denture; whilst in others various orthodontic appliances are used. This stage is carried out when, although the mobility of fragments is arrested by callus formation, yet such callus is still capable of extension and manipulation under mechanical force. Obviously this stage should not be delayed until after the ossification of the callus.

For immobilization of fragments, the cast cap-and-bar splint is universally used, either singly, or in some cases in the intermaxillary form (especially where only a few teeth are available). These splints are easily cleaned, comfortable, and eminently successful.

Fibrous union is treated by a suitable prosthetic appliance. Bone-grafting is being tried in some cases, and we hope to make a communication on the subject later.

Sinuses which persist after two or three curettings combined with the use of 20 per cent lactic-acid packing or chloramine paste, are treated by cutting down upon the bone, exposing it freely, and removing sequestra which maintain the infection.

Limitation of opening the mouth yields more or less readily to intermittent screw-gag pressure (a modified Holt pattern, or lever arm gag), accompanied by massage, which is also given as a routine procedure in the majority of cases of mandibular fracture.

In this series there were 11 cases requiring plastic operations. Three of these only required readjustment of the red margin of the lip, the scar being first excised; and two required the closing of a fistulous communication with the mouth; these call for no comment. Four required more extensive operations on the lower lip. In these and in all such cases where the normal contour of the dental arch is destroyed by loss of teeth, etc., this is restored by a vulcanite appliance which is fitted before plastic procedure is undertaken; this acts as a framework on which to remodel the soft parts. Only one of these cases calls for comment. The patient had had the middle fourth of the lower lip blown away to the depth of one inch. Incisions were made on each side parallel to the lip at the level of the lower margin of the gap, and extending over the mandible to the neck, and the soft parts were freed from the deeper structures sufficiently to allow the two margins of the lip to be sutured and so obliterate the gap. The mouth was thus made slightly smaller, but not unduly so. Of the remaining two cases, one was a scar excision calling for no further notice. The other was a pensioner who, in addition to fracture of the lower jaw, had received considerable injuries to the left cheek and malar bone, with destruction of the facial nerve and left eye. There was drooping of the cheek and left angle of the mouth, causing considerable deformity. An injection of wax was made just above and external to the left angle of the mouth, and a strip of fascia lata half an inch wide was removed from the thigh a few weeks later, after making incisions over the zygoma and above and below the wax depot. The fascia was passed from the zygomatic wound through the cheek substance, first deep to the wax depot, then superficial to it back to the zygomatic wound, where both ends were sutured to the fascia over the zygoma, the angle of the mouth being over-elevated. This operation, combined with scar excision, considerably improved the appearance of the patient.

RESULTS.

Table 3.—Showing the Final Disposal of the Men in this Series of 200 Cases.

Disposal	Number	Percentage
Returned to duty	175	87·5
Discharged from the army	13	6·5
Transferred to other hospitals ..	7	3·5
Pensioners admitted as such ..	4	2·0
Death	1	0·5
Totals ..	200	100·0

The average stay in hospital was 104 days.

This analysis of 200 cases is an attempt to record the ultimate results obtained in some of the earlier cases seen by us in 1916–1917, and it is our hope to publish some further statistics and results of the large number of face and jaw injuries—well over 1000 to date—which have been treated in this special centre.

It is perhaps a truism to mention the invaluable aid in diagnosis and treatment rendered by accurate radiographs taken—as soon as a case is admitted, and serially—to demonstrate the changing conditions as a case progresses, and we have received great assistance in this work from Captain Stansfield, the radiographer to the hospital.

Table 4.—The Results of Treatment in Fractures of the Mandible, with the Sites in which Non-union occurred.

Result	Number	Percentage
Bony union	80	83·9
Non-union, angle	1	1·1
„ lateral	5	5·3
„ mesial	2	2·2
„ multiple	2	2·2
„ ascending ramus ..	5	5·3
Totals ..	95	100·0

In all except three of these cases of non-union the shortest period elapsing between injury and admission to hospital was two and a half months, and the average period was a little over ten months.

The following selection from the above series illustrates some of the typical cases and their subsequent treatment.

Case 1.—Wounded by shrapnel, April 9, 1917. Admitted April 23. Radiography shows a comminuted fracture of the symphysis region, and a triangular fragment detached from lower border of mandible in this region. Alveolar process carrying 5.4.3. practically detached; and these teeth, together with several septic roots of mandibular molars, were removed. On June 4 an intermaxillary cap-and-bar splint (metal Gunning) was adjusted. Sept. 1, splint was removed and union had resulted. Lack of occluding power owing to deficiency of mandibular teeth made good by an artificial denture.

Case 2.—Bullet wound, Nov. 13, 1916. Admitted Jan. 3, 1917. Previously, a cap splint had been cemented in place. Oral condition extremely septic. No union had occurred. Wound of entry still persisted on right side of chin. Point of exit was on left side of chin, and a comminuted fracture in the right canine and premolar region resulted. There was some displacement, the lesser fragment had been drawn inwards, to be overlapped by the larger (left) fragment, which had been drawn round to injured side. Second premolar of left side was seen to be directly in the area of fracture, and was removed. Although tissue lost is considerable, several bony foci remain—which are of essential value in ultimately gaining bony union. Sinus persisted at wound of entry, but eventually healed. Submental abscess also developed; this delayed complete immobilization (a cap splint being worn loosely for a time, so that the displacement was overcome), which was eventually practicable on Feb. 2. May 7, splint removed and jaw quite firm, with bony union. Patient discharged to duty June 15.

Case 3.—Fracture at the right angle of the mandible without comminution or loss of tissue. Patient wounded, Oct. 17, 1916, and an intermaxillary splint was adjusted in France. Bullet entered left cheek, whilst the point of exit was immediately below lobule of right ear. On admission, Jan. 6, 1917, oral condition was bad and pronounced sepsis very apparent. Splint was removed and no union had resulted. Radiography shows the right mandibular third molar directly involved in line of fracture; it was consequently removed, together with several septic roots in the maxilla. A sinus existed beneath right ear and persisted for some time. The oral condition at length being satisfactory, an intermaxillary splint was adjusted, and on June 15 the patient was discharged to duty. Limitation of opening had resulted, owing to involvement of masseter and internal pterygoid muscles as well as prolonged closure during the period of immobilization, but was rapidly overcome by intermittent gagging and massage.

Case 4.—Complete fracture of condyle across its base. Wound received Oct. 12, 1916, and man admitted, Nov. 14. Entry wound existed on left cheek, immediately above middle of zygomatic arch. The mandibular and maxillary teeth were wired together in France. On admission, the clinical condition was that of limitation in opening mouth, with salivary fistula in left cheek, which was treated by introduction of a silver tube. No clinical evidence of mandibular fracture, and after the condition of 'false trismus' had been overcome by massage and gagging, the patient was discharged to duty, May 18, 1917.

Case 5.—Double fracture of right body of the mandible. Patient wounded by high-explosive shell, April 25, 1917, there being a large entry wound on right side of neck. An intermaxillary splint (metal Gunning) had been cemented in place, an excess of cement being present; a large piece of composition covered part of it, evidently to protect the tongue from injury. On

admission, May 18, mouth was found in a very septic condition; radiography shows an oblique fracture posterior to last molar tooth, in which a portion of tooth-root and mandibular molar tooth are involved, and a second fracture in right canine region, involving that tooth. A freely-discharging sinus was present at the entry wound. The splint was removed, and the above-mentioned teeth. June 5, the sepsis had subsided and sinus healed, so that an intermaxillary cap-and-bar splint was cemented in place. This was eventually removed to allow the extraction of second and third right maxillary molars, which were seen to preclude the forward movement of posterior fragment. A splint was again adjusted, and removed on Aug. 3, when it was found that fibrous union (pseudo-arthrosis) had resulted. A prosthetic appliance was provided which rendered mastication quite efficient, and the man was ultimately discharged to duty (C 3). This case shows the evil effects of delay in removing involved teeth, of the presence of uncontrolled sepsis, and finally of neglect to allow the forward transition of the posterior fragment, all of which combined to produce non-union.

Case 6.—Wounded, Sept. 25, 1916; admitted, Nov. 3. Injury due to a bullet which, entering left angle of mouth, issued about 1 in. above the right angle. Radiography shows comminuted fracture of right angle of mandible, and a second fracture extending obliquely through the right body in the first mandibular molar region. Roots of two mandibular molars and the second premolar appear to be impacted in the fracture. A Hammond splint had been adjusted, and was removed, together with the molar and premolar roots and several maxillary teeth. Mouth in very septic condition. Nov. 15, an intermaxillary cap-splint was cemented in place, and when removed on Dec. 15, jaw was firm, and bony union obtained. This man was discharged to duty subsequently.

Case 7.—Incomplete fracture of left body of mandible, only the lower border of jaw being involved; there was no clinical evidence of fracture. Wounded, July 30, 1917; admitted Aug. 13. Patient was discharged to duty on Sept. 10: the only treatment necessary was the removal of 7.5.4., which were quite loose.

In conclusion, we should like to thank Lieutenant-Colonel H. Littlewood, C.M.G., administrator of the hospital, and consulting surgeon to this department, whose valuable advice and courtesy have been of real assistance in our work.

PRIMARY AND DELAYED PRIMARY SUTURE OF GUNSHOT WOUNDS.

A REPORT OF RESEARCH WORK AT A C.C.S., DEC., 27, 1917—MARCH 1, 1918.

Director of Research Work: CAPTAIN FORBES FRASER.

Operating Surgeons: CAPTAINS J. W. DEW, D. C. TAYLOR, A. W. DENNIS, M. W. B. OLIVER, and HENRY STOKES. *Radiologist:* CAPTAIN N. S. FINZI. *Anæsthetists:* CAPTAINS G. MARSHALL, C. F. HACKER, A. S. BLACKWELL, and LIEUTENANT G. R. PHILLIPS. *Physician:* CAPTAIN J. A. RYLE.

WITH WHICH IS INCLUDED A

REPORT ON THE BACTERIOLOGY OF WOUNDS.

BY CAPTAIN ADRIAN STOKES AND MAJOR W. H. TYTLER.

I. GENERAL OBSERVATIONS.

FOR the purposes of this work during the period mentioned, only men suffering from wounds of the upper and lower limbs have been admitted to the C.C.S. Of these, 60·8 per cent have been entered on the research list as being cases suitable for immediate or early suture.

Patients suffering severely from shock and loss of blood, who are not in a condition to bear a thorough cleansing operation, and whose tissues may have lost much of their normal power of resisting infection, are not as a rule suitable subjects for primary suture, though they may sometimes be fit for closure of their wounds after the lapse of a few days. Patients who show signs of already established infection of the tissues surrounding the wound must also be rejected; these form a large class, and include the majority of men whose arrival at the C.C.S. has been delayed beyond twenty-four hours. Multiple wounds are seldom suitable, not only on account of the lengthy operation involved, but because of the likelihood of one failure causing infection of other wounds. Trivial wounds, and clean through-and-through bullet wounds without damage to main vessels or nerves, are also best left alone. Patients considered unsuitable for the research list are treated by us in the usual way, and evacuated to the base when they have sufficiently recovered.

Patients whose wounds have been sutured are kept here till their wounds have healed, or until the treatment has definitely failed. We have, as far as possible, limited our investigations to primary suture at the time of operation, and to delayed primary suture, which may take place at any subsequent time before granulations have formed.

Secondary suture, by which we mean suture after granulations have formed, we have reserved chiefly for wounds with virulent infections such as those in which primary suture has failed on account of the presence of hæmolytic streptococci. We feel that secondary suture is better investigated at the base and in England, where so much important work has already been undertaken in this direction.

Reference to the figures in Part II will show that the vast majority of the wounds which we have dealt with were infected before operation. Success in primary suture must, therefore, depend on early operation, whereby the infected area may be more or less thoroughly removed before sufficient time has elapsed to allow of infection penetrating into the surrounding tissues.

As this removal can rarely be complete, other factors are :—

1. The ability of healthy tissues to deal with a limited amount of infection, provided the larger sources of bacterial growth have been removed.

2. The possible action of chemical antiseptics in destroying or inhibiting the growth of bacteria still present after operation.

With these principles in mind we have operated on a series of cases, the details of which will be found in Part II.

Antiseptics.—We have sutured wounds without the aid of antiseptics, and we have also used B.I.P.P., flavine, and, more recently, dichloramine-T dissolved in chlorinated soft paraffin (chlorcosane). Some of the wounds have been treated by washing with ether, after the method in common use by French surgeons. Soap solution, which has of late been used with success by Captain Haycraft and others, is also being tried by us. The numbers of wounded who have been admitted are too small to enable us at the present time to draw definite conclusions as to the relative value of these chemicals. At present we can go little further than to show it is possible to suture wounds with considerable success with the use of each of these substances, and also without any antiseptics at all.

Before describing in detail the methods we have used, we wish to acknowledge our indebtedness to many papers on the subject of primary suture published by French surgeons, and in particular to the article by M. le Gros (*Bulletin de la Société de Chirurgie*, October, 1917), which forms the basis of the work we have undertaken, although the mode of operation adopted by us differs from that advocated by him.

X Rays.—Every case, excepting through-and-through wounds or contour wounds with no damage to bone, is examined by *x* rays before operation. We understand that it is a common event after a foreign body has been removed at the C.C.S., for surgeons at the base to find others present which keep up sepsis. It is, therefore, unjustifiable to close a wound till it is certain that all foreign bodies have been removed.

Culture.—A specimen is taken from each wound for culture immediately before operation. For this purpose a swab is used, contained in a glass tube in the upper end of which cotton-wool is packed. The whole is placed in a test-tube, the mouth of which is also plugged with wool. The apparatus is sterilized in the autoclave, and when the specimen is to be taken, the inner glass tube with the swab is withdrawn and placed in contact

FIG. 81.—Stokes' swab and tube used in taking specimens for culture.

with the wound. The swab is then thrust down into the depths of the track and thoroughly smeared on all parts of the wound which can be reached. It is then withdrawn into the tube, and both are replaced in the test-tube. This method of taking specimens, which appears to us to be efficient, and to guard against contamination, we owe to Captain Adrian Stokes (*Fig.* 81.).

Disinfection of Skin.—The patient's skin is shaved, washed with soap and water followed by spirit, then painted freely with a 5 per cent solution of picric acid in spirit.

Operation.—We wish to lay stress on the fact that, excepting only comparatively superficial wounds which could be excised as a whole without doing serious damage to the limb, no attempt has been made by us in the course of this work to perform excisions *en bloc*. Most of the French surgeons who advocate primary suture of gunshot wounds appear to aim at aseptic excisions in which dead or soiled surfaces are not touched with the knife or scissors. Thus, they recommend that a lodging wound be treated by excision in the form of a cone which includes the foreign body and its bed at its apex ; a through-and-

through wound by the excision of two cones whose apices meet ; a compound fracture by ablation of a wedge of soft parts down to the bone. Their object is to avoid entering the track, and to render the operation as nearly an aseptic one as possible, a method similar to that used in civil practice for the removal of a malignant growth.

We feel that this ideal method, even when anatomically possible, is only applicable to exceptional cases in which it can be carried out without doing serious injury to muscles and other structures of the limb. To use it in deep lodging wounds, in through-and-through wounds, and in the general run of compound fractures, would in our opinion lead to unnecessary loss of tissue, and often to irreparable damage to the function of the limb.

Our method has been to excise a very narrow margin of skin round the wound in the form of an ellipse, to prolong the incisions sufficiently to obtain a full exposure of the track, and then, with the help of good retraction, to remove its walls with scissors or knife. As little healthy tissue as possible is removed ; but soiled, dead, or severely bruised muscles are snipped away till healthy contracting and bleeding tissue is exposed.

It will be seen that this form of piecemeal excision of wounds, being performed to a great extent from within the track, has no pretension to being an aseptic operation, and differs entirely from ideally aseptic excision *en bloc*, which aims at removing the whole track from outside without cutting into it. Success in suture after excision piecemeal must depend on the ability of healthy tissues, aided perhaps by chemical antiseptics, to deal with infection, provided the latter be not too massive or too virulent.

A proportion of failures must be expected, in the presence of virulent infection, even if the operation has been properly performed. A method such as this, whose success depends to a great extent on factors of which we are ignorant, is obviously open to criticism. Its scope, however, is so much larger than that of excision *en bloc*, and its advantages over the latter in avoiding unnecessary removal of tissue are so important, that if in practice the results obtained by it are proved to be sufficiently good, and the risks attending it to be sufficiently small, then the use of piecemeal excision appears to us to be justified. While in the presence of infection this operation can never be aseptic, yet there are degrees of soiling of raw surfaces, and every precaution should be taken to avoid unnecessarily contaminating the rest of the wound from dead and infected material. By means of free incision good access should be obtained to every part of the wound, and with the aid of retractors all excision should be carried out under view. The use of the fingers to explore tracks should be absolutely discountenanced. By changing of instruments or by frequently rinsing them in 1–20 carbolic, and by care in manipulation, gross soiling of raw surfaces can, as a rule, be avoided. The operation is not complete till every part of the wound has been dealt with, and every fragment of dead muscle removed. Important structures, such as main vessels and nerve trunks, which cannot be excised, should be carefully cleaned with knife, scissors, and swabs. If every part of the track has not been actually seen and cleansed, primary suture should not, as a rule, be undertaken.

The use of dyes, such as 5 per cent solution of methylene blue or brilliant green in 20 per cent formalin, has been advocated, particularly by French surgeons, as a means of distinguishing living from dead tissue. Experiments have been made by us in the use of these dyes, with the result that there is some individual difference of opinion as to their value. They certainly stain dead tissues deeply and intensely, while the cut surface of living muscle is only lightly stained on the surface. We are inclined to think that their use may be of some value in dealing with large wounds where small patches of dead tissue are apt to escape attention, and also should be a help to operators who have not much experience in the excision of gunshot wounds.

Compound Fractures.—In the case of compound fractures, the wound in the soft tissues is dealt with as above described, and a good view of the fracture being obtained by retraction, the cleaning of the bony lesion is proceeded with. Foreign bodies are removed, loose fragments lifted out, and sharp points cut off. Access is gained to the fractured surfaces by levering fragments apart, and every crevice is carefully cleaned by small spoons, scrapers of various shapes, and burrs. Blood-clot is carefully wiped away from cracks in the neighbourhood of the main fracture.

We are careful to remove as little bone as possible, knowing that regeneration of bone is a difficult and tedious process. Only fragments which have lost all their attachment are removed; those retaining even a small connection with periosteum are preserved.

The closure of cavities left in bone after the removal of a foreign body or loose fragments often presents considerable difficulties. Such cavities, if left to fill with blood-clot, generally become septic and lead to failure of the operation. In one such case (a femur), a muscle flap with good blood-supply was cut from the vastus externus and made to fill the cavity; unfortunately it sloughed, infection with anaerobes took place, and the wound had to be opened. Fat grafts have been used by several of us with success in the neighbourhood of the knee-joint. Up to the present time our experience has not been sufficient to enable us to express an opinion as to the best method to be adopted.

The investigations of Major Martin on the spread of infection in compound fractures (BRITISH JOURNAL OF SURGERY, October, 1917) are of great importance in connection with the early treatment of these injuries. He has demonstrated that penetration of bone by infection is slow in comparison with its rate of progress in soft tissues. It seems reasonable, therefore, to presume that if the infected soft tissues have been efficiently removed and the damaged surfaces of the bone thoroughly cleansed, sepsis will not occur in the bone, and a compound fracture should be expected to heal by first intention in the same way as a flesh wound. This is borne out by our experience.

The operation is completed by careful *hæmostasis*. For smaller vessels this is best secured by leaving on pressure-forceps, such as Lane's, during the operation. Larger vessels must be ligatured with catgut, but care taken that as little tissue as possible is included in the ligature. All crushed and ligatured tissue must die, and the less dead material left to form a nidus for infection the better.

It has now to be decided whether to suture the wound at once or to leave it open. Every case must be judged on its merits, and it is impossible to lay down rules which will cover all eventualities. The size, gravity, and appearance of the wound, the time which has elapsed since its infliction, and the condition of the patient, must all be taken into account. The following may be found useful as a guide in general terms. Provided (1) that the wound is not of more than fifteen hours' duration ;* (2) that the surgeon feels that he has been able to cleanse it satisfactorily, and has removed all foreign bodies ; (3) that closure can be effected without undue tension ; and (4) that the patient need not be moved for several days at least : then primary suture is justifiable. Otherwise it is advisable to leave the wound open in the hope of suturing it at a later date. Undermining of skin flaps, and other plastic measures for closing wounds, should not, as a rule, be undertaken at the primary operation, unless a bacteriological examination has already been made and it is certain that virulent organisms are not present.

Suture.—It is important that accurate coaptation of deep, as well as superficial, surfaces be obtained. 'Dead spaces' which fill with blood-clot will probably lead to failure. We have adopted the method of passing deep coaptation sutures which draw together the muscles and emerge from the skin wide of the edges of the wound. If tension is present these are tied over rubber tubes or lead plates. The skin edges are then brought together by interrupted sutures, with an interval of $\frac{1}{2}$ to $\frac{3}{4}$ inch (see *Figs.* 121, 125). We have avoided buried catgut sutures, except in wounds of joints where they have been used to close the synovial membrane. For suture material we have used silkworm gut, and silk treated with B.I.P.P. The latter has the advantage of being well tolerated by the tissues, and produces little irritation even when retained for long periods. Owing to its thickness it is not so liable as silkworm-gut to cut out. Sizes 4 to 6 China twist are used. It is prepared by boiling in carbolic (1–20) for an hour, subsequently soaking in tincture of iodine overnight, and then storing in a very liquid B.I.P.P.

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* The limit of fifteen hours after infliction of the wound is about the average for wounds of moderate severity, after which we consider it wise not to attempt immediate closure. Many slighter wounds have been successfully sutured at later periods.

Drainage.—We have found that as a general rule it is better to dispense with drainage altogether. The use of rubber drainage tubes is certainly to be avoided. They appear to act as foreign bodies, and sepsis is prone to appear in their tracks, even if the tube is removed at the end of forty-eight hours. 'Viennese silk wire,' consisting of bronze aluminium wire with a fine silk core, which is recommended highly for use as a drain by French surgeons, has been tried by us. Though it acts efficiently as a drain, it appears to have the same disadvantages as rubber tubes, and to set up irritation and consequent sepsis which may lead subsequently to infection of the whole wound. If interrupted sutures are used, and not placed too close together, sufficient escape of blood and serum generally takes place between them, and further drainage is unnecessary. In the presence of persistent oozing, which in civil surgery would generally be treated by introducing a tube for a short time, it is better to pack the wound, leave it open, and suture it at the first dressing.

Progress and After-Treatment.—Our treatment has been, as stated already, to excise and suture wounds without knowing the nature of the infection at the time of operation. No other course is possible in the primary suture of gunshot wounds, as to wait for cultures to be made and examined before operating would involve certain failure in the majority of cases, owing to infection spreading during the interval into the tissues surrounding the wound. Generally, however, on the morning following operation we have had the advantage of knowing the results of both aerobic and anaerobic culture from each wound.

We have found that among the many kinds of infection which are present in the majority of the wounds with which we have dealt, one variety, viz., the *hæmolytic streptococcus*, stands out as being in a class by itself in virulence. A sutured wound infected by these organisms will almost certainly go wrong, and unless the sutures are removed at once and energetic measures taken to combat the spread of infection, not only the limb but even the life of the patient may soon be in grave danger. Other infections which we have met with in sutured wounds need not, in our experience, as a rule give rise to anxiety on the part of the surgeon, and do not often call for urgent interference. Streptococci which are not hæmolytic occasionally give rise to acute symptoms, but in our experience the majority of wounds infected by them do well. Infection by the common varieties of anaerobes alone does not appear to be of much importance, provided a careful operation has been done. The tissues will probably be able to deal with them, and if suppuration takes place it is likely to be local and easy to control. The hæmolytic streptococcus, on the other hand, *always* gives rise to anxiety on our part, and nearly always necessitates the opening of the wound. The advantage of early knowledge of the presence or absence of these organisms is, therefore, in our experience a very real one.

The statement that the hæmolytic streptococcus is by far the most virulent organism which we have hitherto met with in the wounds which we have sutured must not be taken to mean that we wish to deny that other organisms of equal virulence may sometimes infect gunshot wounds. We have some reason to believe that such organisms do occur, but we have not met with them in our present series of wounds considered suitable for early closure.

The characteristic feature of the post-operative condition of patients whose wounds have been sutured and are healing, is the general well-being of the men. They look well, are cheerful, have good appetites, and as a general rule have very little pain. There is a marked contrast between their aspect and that of patients with open suppurating wounds. Many patients have little constitutional disturbance after operation; but a rise of temperature lasting for one, two, or three days, or even longer, is common. There may also be a raised pulse-rate, though as a rule the pulse does not remain for long above 100 except in cases of very severe wounds or of streptococcal infection. If the bacteriologist has reported that hæmolytic streptococci are absent, mere elevation of temperature and pulse in a patient who looks and feels well and complains of no pain in his wound by no means indicates impending suppuration. In all probability the fever will subside in the ocurse of a few days and healing will take place by first intention.

Sometimes local suppuration will occur, occasionally a gas-containing abscess may form; in either case the removal of one or more stitches and the introduction of sinus forceps will probably be all the treatment required. When the infection is by non-hæmolytic streptococci or staphylococci, these simple measures are less likely to succeed, and the wound may have to be completely opened up. Late onset of pain, which was at first absent, and a temperature curve tending to rise instead of fall, are the usual indications of suppuration.

The general aspect of a patient whose wound is infected with hæmolytic streptococci is in the vast majority of cases entirely different. He is anxious, looks ill, complains of pain in his wound, often severe, refuses food, and sometimes has nausea or vomiting. His temperature and pulse are on the up grade, and on dressing his wound the skin around it for some distance will be found to be œdematous and covered with a dull red or bluish-red blush; serum pours out from the wound, often so profusely as to saturate the dressings. No time should be lost in opening such a wound widely and beginning treatment with some antiseptic such as Carrel Dakin, flavine, or B.I.P.P.

The points which are of value in clinically distinguishing infection by hæmolytic streptococci from other conditions are, therefore: (1) general aspect and condition; (2) pain in wound; (3) appearance of wound and exudation of serum. If the symptoms and appearances of this virulent infection are so distinctive, it may be argued that bacteriological examination may be safely dispensed with as an adjunct to early suture of wounds. There can be no doubt that the difficulty of preparing cultures in large numbers, if such cultures are necessary in every case, must militate considerably against the use of primary or delayed primary suture during periods of active fighting. Unfortunately the symptoms are not always so clear as we have described them above in typical cases. Sometimes a patient with only a mild infection, or with no infection at all, will have severe pain in his wound, will feel sick, and look ill, and on removing the dressings a considerable exudation of serum will be found. Without the assurance of the bacteriologist that hæmolytic streptococci are absent, the surgeon must open the wound, as he is in doubt, and cannot afford to run risks. On the other hand, we have known a case heavily infected by these organisms heal by first intention without either local or constitutional reaction.

The Chart shown in *Fig.* 104 illustrates the kind of difficulty which may arise. *Cases A* and *B*, operated on the same evening, next morning presented almost identical clinical conditions. The bacteriological report indicated that *A* required immediate treatment, while *B* might safely be left alone. Without the aid of this report it is very probable that *B*'s wound might have been opened, and a good result thus spoiled.

Such experience as we have gained leads us to believe that, while the services of a bacteriologist are of the greatest advantage to the surgeon in doing this work, and that without his help the best results cannot be obtained, yet it is possible to depend on careful clinical observation alone, though in this way many wounds may have to be opened up which would heal by first intention had the required bacteriological report been available. In the absence of sufficient bacteriologists to prepare cultures for all wounds, their services should be reserved for the examination of those of the more severe type.

Dressings.—Cases which are obviously doing well are usually dressed at the end of forty-eight hours, after which it is unnecessary to change the dressings for eight or ten days, when the sutures may be removed. If there has been tension, however, it is advisable to leave the deep sutures considerably longer. Wounds which have been treated with B.I.P.P. should retain at least some of their sutures for two or three weeks, as wounds so treated appear to take longer to unite than the average. Unnecessary dressing of these wounds is harmful; we have frequently seen patients the worse for it. Physiological rest is the most important feature of their after-treatment. It is necessary to bear in mind that the vast majority of these wounds, though they may be clinically aseptic, are not bacteriologically sterile, and this is the probable explanation of the undoubted fact that sutured wounds, if transferred to the base in their early stages, so frequently go wrong. The jolting and shaking of the journey is

sufficient, by causing slight further traumatisms, to enable already existing infection to gain the upper hand.

Massage and Movement.—Massage for the limb may be carefully begun as soon as healing is complete, but it should not at first be applied near the wound. After the third week gentle massage may be allowed round the wound, but not in cases that have had streptococcal infection, which is easily lighted up afresh even after the lapse of many weeks. In the case of flesh wounds the patient may be allowed to move his injured muscles himself as soon as the wound is soundly healed. He may be trusted not to do damage by too violent efforts. Passive movements should certainly not be allowed till after the lapse of a month in ordinary cases, and a much longer period in cases infected by streptococci. They may do much damage in lighting up sepsis, and where the original infection has been virulent they are dangerous.

Delayed Primary Suture.—The excised and cleaned wound is treated with some antiseptic, such as B.I.P.P., flavine, or dichloramine-T, and lightly packed with gauze. The sutures may be placed in position at the primary operation and left loose, or they may be inserted at the time of closing the wound. In either case the same care as in primary suture is necessary to secure perfect apposition of deep as well as superficial surfaces. The liability of open wounds to become infected with staphylococci, probably from the skin, renders it advisable to use antiseptics as a routine measure. We have employed each of the above-mentioned with success. The question of antiseptics will be further discussed under a separate heading.

Except in cases when the bacteriologist has reported the presence of hæmolytic streptococci in the first culture (taken before operation), our practice has been to close the wound in from two to four days, provided that it appears clean and healthy when dressed, and the patient's general condition is satisfactory. The suturing has been performed usually under gas and oxygen, but several operations have been satisfactorily carried out under Gwathmey's method of oral anæsthesia.

If it is decided to postpone suturing still further, a culture or smear is taken, and the wound re-dressed. Except in the presence of streptococci, our practice has been to rely on clinical indications rather than on bacteriological findings. If hæmolytic streptococci are present in the first culture, we do not attempt suture till the patient's temperature has been normal for some days, till his wound looks clean and healthy, and till smears taken from it give a count of not more than one coccus per field. This rule does not apply to amputations performed through uninfected tissue above an infected wound: the stump can usually be safely closed in two or three days. We find that a wound infected with hæmolytic streptococci does not often reach the suture stage for about fourteen days.

The healing of wounds closed a few days after the primary operation appears to us to be nearly equal to the results obtained by immediate suture.

The softness and pliability of the scars obtained by these methods, the absence of hard contracting masses of fibrous tissue and of pain and tenderness at the site of the wound, and the rapid recovery of function, form a marked contrast with the results so often seen when wounds have been allowed to heal by granulation.

After-Treatment of Compound Fractures.—From inquiries at the base and in England, we understand that fractures travel best within the first few days after operation at the C.C.S., or in their later stages, on the other hand, after some degree of union has been obtained. Patients who travel in the intermediate stages are liable to develop severe outbreaks of sepsis. We have therefore kept our compound fractures at the C.C.S. for a considerable time, in many cases till firm union has taken place.

Two huts were equipped with suspension apparatus in the following manner: 1-in. iron piping, hung by brackets, was run along the whole length of the hut, in a vertical plane 1 in. beyond the ends of the beds; on a level with this, 3½-in. by 1-in. planking, with notches cut in its upper border at 4 in. intervals, was nailed to the wall, also along the whole length of the hut. A number of movable cross-pieces were made, of 3½-in. plank, one end of which rested in the notches and the other on the iron piping. A

firm bar, which could be placed in such a position over the patient's bed as to obtain any degree of abduction required, was thus provided for suspension of the lower limb. Vertical bars were also made, with a notch to fit on to the iron piping, and of such a

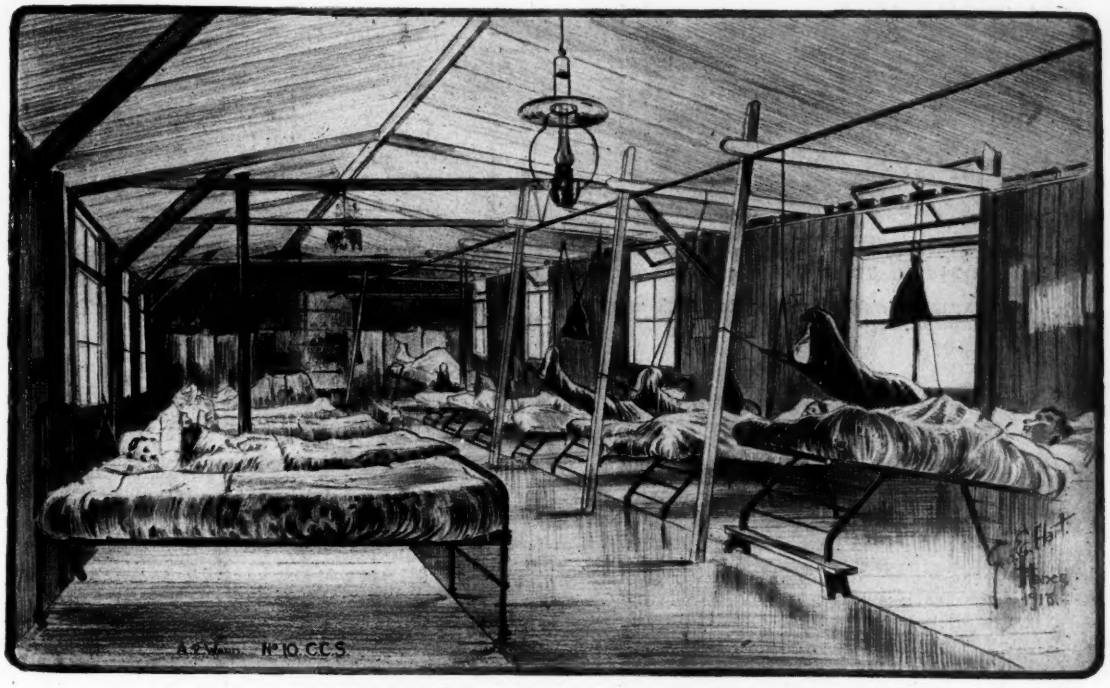


FIG. 82.—Showing a hut with suspension equipment.

length that with the notch in position they reached the floor with a slight inclination away from the foot of the bed. Weight extension was obtained by means of pulleys attached to the vertical bars at any level required (*Fig.* 82).

Individual Fractures.—*Femur.*—Fractured femurs were treated on Thomas splints, generally bent opposite the knee to a greater or less extent according to the displacement to be rectified. In most cases a fixed extension was used by means of glue and strips of gauze. This was usually supplemented by weight extension attached to the end of the splint, in order to relieve pressure of the ring on the tuber ischii. In one case in which considerable flexion of the knee was necessary, and large wounds prevented the application of glue or plaster, weight extension was obtained by the use of the caliper invented by Major Besley, U.S.R.

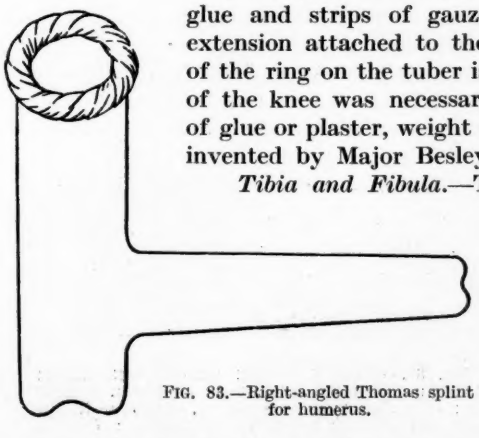


FIG. 83.—Right-angled Thomas splint for humerus.

Tibia and Fibula.—These were commonly treated on slightly flexed Thomas splints with the addition of a Sinclair foot-piece for extension. Hey Groves's skeleton inclined plane with foot-piece was also used.

Humerus and Elbow.—These fractures were always treated with the elbow flexed at right angles, generally from the beginning, and if not, after the first few days. In the early stages shutter splints were sometimes used, and the limb was suspended by flannel strips from an iron wire trapeze in the position of full abduction of the shoulder. The trapeze itself was suspended by weight and pulley. Later these fractures were put up in

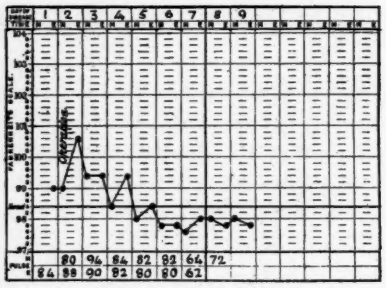


FIG. 84.—PRIMARY SUTURE (B.I.P.P.). Shell wound both buttocks; excision and suture; healing by first intention.

INFECTION: *Aerobic*, short non-hæmolytic streptococci; *anaerobic*, negative.

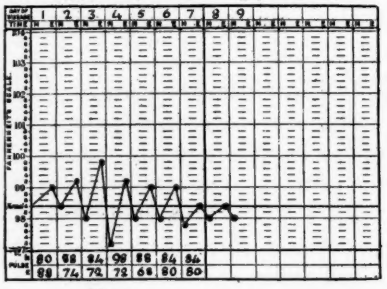


FIG. 85.—PRIMARY SUTURE (DICHLORAMINE-T). Shell wounds left thigh, and through-and-through right calf; excised and sutured; healing by first intention.

INFECTION: *Anaerobic*, gas-forming bacilli; *aerobic*, staphylococci and bacilli.

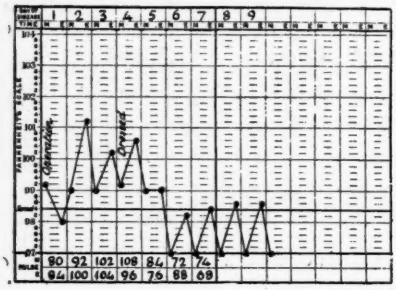


FIG. 86.—PRIMARY SUTURE (B.I.P.P.). Bullet wound right knee (not penetrating joint); excised and sutured; healing by first intention.

INFECTION: *Aerobic*, staphylococci and non-hæmolytic streptococci; *anaerobic*, negative.

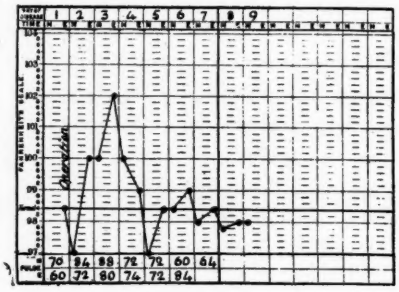


FIG. 87.—PRIMARY SUTURE (ETHER). Shell wound right thigh, track 6 in. long × 1½ in. deep; excised and sutured; healing by first intention.

INFECTION: *Aerobic*, bacilli and short non-hæmolytic streptococci; *anaerobic*, B. Welchii.

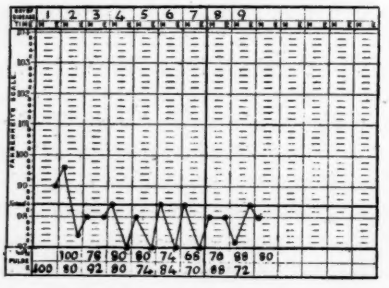


FIG. 88.—PRIMARY SUTURE (B.I.P.P.); COMPOUND FRACTURE. Shell wound foot; compound fracture 4th and 5th metatarsals, cuboid, and internal cuneiform; wound excised and left open; sutured completely on third day; complete healing.

CULTURES: Negative.

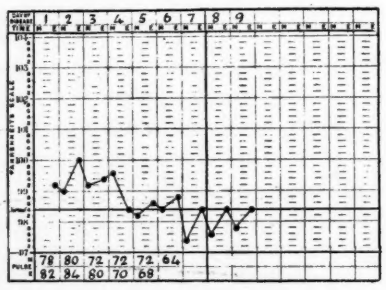


FIG. 89.—PRIMARY SUTURE AND TENDON SUTURE (B.I.P.P.); COMPOUND FRACTURE. Shell wound right ankle; compound fracture astragalus, division of tibialis anticus and extensor longus hallucis tendons; excision of wound, suture of tendons, primary suture; healing by first intention.

INFECTION: *Aerobic*, bacilli; *anaerobic*, negative.

Thomas splints bent at right angles at the elbow (*Fig.* 83), with fixed extension by means of glue and gauze strips.

Forearm.—Hey Groves's open wire splint was found satisfactory in the treatment of these fractures. By its means the position of supination is easily obtained.

If extreme care be exercised, we believe that no serious disaster should occur as the result of early suture, though to estimate accurately the amount of damage done by primary suture to a patient whose wounds are infected with virulent streptococci is a difficult matter. As far as we have seen, if the stitches are taken out in good time, little harm has resulted from the wound having been closed for a short period. It is certain, however, that undue delay in re-opening these wounds would inevitably lead to grave disasters.

The accompanying series of Charts (*Figs.* 84–104) is illustrative of the clinical course of wounds treated by these methods, and includes varying types from simple flesh wounds to severe compound fractures and amputations. Failures due to virulent infection are shown, as well as cases in which union per primam has been attained.

A number of skiagrams and drawings are also given, showing some of the wounds which have been sutured with more or less success (*Figs.* 105–125).

II. STATISTICAL SUMMARY.

1. **General.**—The total number of wounded men admitted to the C.C.S., from Dec. 27, 1917, to March 1, 1918, was 498.

Cases unsuitable for suture	195 = 39·2	per cent
Cases entered on list for suture ..	303 = 60·8	„ „

Of the 303 cases entered on the research list, primary or subsequent suture of their wounds was actually carried out in 285.

In 13 cases, it was found impossible to close the wounds within a reasonable time after operation, on account of loss of tissue or of severe sepsis.

Of the patients on the research list, 7 died, 4 before any attempt had been made to suture their wounds, and 3 subsequently to complete or partial suture.

The *mortality* amongst the 285 cases whose wounds were sutured amounted therefore to 3, or about 1 per cent.

Total cases sutured		285
Cases still incomplete for report	13	
Secondary sutures not included in report	8	
	—	21
Total cases reported on (including 3 patients who died)		264

The number of wounds in the 264 cases amounted to 315; for the purposes of this report it is convenient to consider each wound as a separate entity, and the following figures refer to wounds and not to individual patients (with the exception of No. 2).

2. **Interval between Wound and Operation.**—

Average interval in all cases	11·7	hours
„ „ in successful cases ..	10·7	„
„ „ in failures	12·1	„

The earliest successful primary suture was performed two and a half hours after infliction of the wound, and the latest (for a slight wound of the arm) thirty-seven hours afterwards.

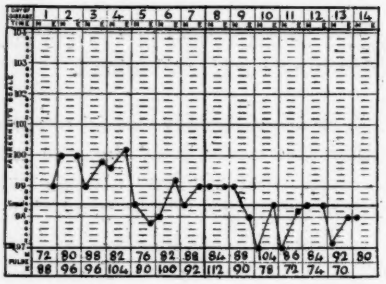


FIG. 90.—PRIMARY SUTURE (B.I.P.P.); COMPOUND FRACTURE. Shell wounds elbow and buttock; compound fracture humerus and ulna into joint; buttock wound excised and sutured; elbow wound excised and fracture cleaned; healing by first intention in both cases.

INFECTION: Elbow—*Anaerobic*, bacilli without gas; *aerobic*, long streptococci (non-hæmolytic). Buttock—*Anaerobic*, B. Welchii, streptococci; *aerobic*, short non-hæmolytic streptococci, staphylococci.

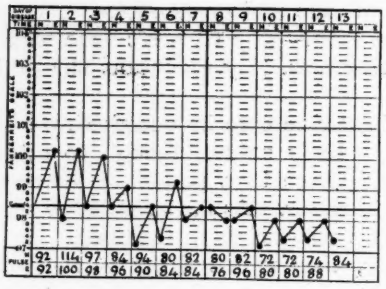


FIG. 91.—PRIMARY SUTURE (ETHER); COMPOUND FRACTURED HUMERUS. Severe comminuted fracture of humerus, with wounds of arm and forearm; wounds excised and fracture cleaned, complete suture; healing by first intention.

INFECTION: *Anaerobic*, bacilli without gas; *aerobic*, negative.

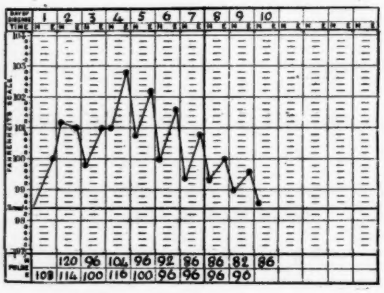


FIG. 92.—PRIMARY SUTURE (SALINE); DELAYED PRIMARY SUTURE (FLAVINE). Shell wounds left thigh and buttock, and left arm; wounds excised; buttock wound left open and packed with flavine; arm wound sutured without antiseptic; buttock wound sutured after 48 hours; both wounds healed completely.

INFECTION: Arm wound—negative. Buttock wound—*Anaerobic*, gas-forming bacilli; *aerobic*, non-hæmolytic streptococci.

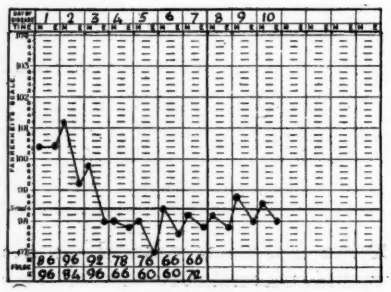


FIG. 93.—DELAYED PRIMARY SUTURE (FLAVINE). Through-and-through wound of calf; excised and left open, packed with flavine gauze; sutures inserted at primary operation but not tied; sutures tied 48 hours later; complete healing.

INFECTION: *Anaerobic*, gas-forming bacilli; *aerobic*, long-chained non-hæmolytic streptococci.

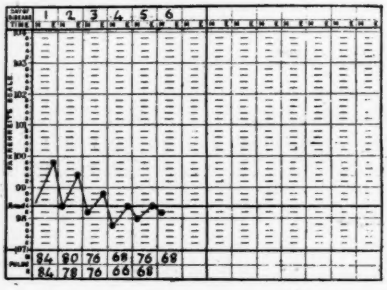


FIG. 94.—DELAYED PRIMARY SUTURE (FLAVINE). Shell wound forearm, foreign body firmly embedded in ulna; wound excised and foreign body removed, left open and dressed with flavine gauze; sutured on third day; healing by first intention.

INFECTION: *Anaerobic*, cocci; *aerobic*, non-hæmolytic streptococci.

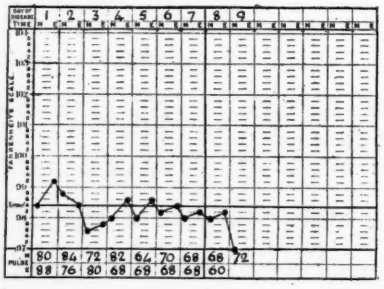


FIG. 95.—DELAYED SUTURE; COMPOUND FRACTURED HUMERUS. Shell wound of arm; compound fracture of humerus; wound excised and left open; flavine pack third day; suture; healing by first intention.

INFECTION: *Anaerobic*, cocci; *aerobic*, negative.

3. Primary Suture.—

Complete primary union	146	= 80 per cent
Partial „ „	33	
Failures	45	= 20 „ „
Total wounds	224	

4. Delayed Primary Suture.—

Complete primary union	78	= 96 per cent
Partial „ „	16	
Failures	4	= 4 „ „
Total wounds	98	

5. Comparison of Results of the Use of Antiseptics, etc.—

No Antiseptic.		
Primary suture: Primary union (complete or partial)	37	
Failures	4	
Total wounds	41	
Soap.		
Primary suture: Primary union (complete or partial)	22	
Failures	7	
Total wounds	29	
Ether.		
Primary suture: Primary union (complete or partial)	46	
Failures	9	
Total wounds	55	
Flavine.		
Immediate suture: Primary union (complete or partial) ..	24	
Failures	4	
Total wounds	28	
Delayed suture: Primary union (complete or partial)	60	
Failures	3	
Total wounds	63	
B.I.P.P.		
Immediate suture: Primary union (complete or partial) ..	52	
Failures	16	
Total wounds	68	
Delayed suture: Primary union (complete or partial)	31	
Failure	1	
Total wounds	32	

The number of wounds treated by dichloramine-T is at present so few that we have not included them in the statistics of antiseptics.

These figures are, obviously, too small to form a basis for comparison of the value of the different substances used. Large numbers would be necessary in order to eliminate coincidence, seeing that the severity of the wounds and the nature of the infection are so variable. Further, the natural tendency of every surgeon is to use the antiseptic in which he has the most confidence in the treatment of severe wounds. Thus, with a few exceptions, only the slighter wounds have been treated without antiseptics, and this may account for the results without antiseptics being the best (90 per cent of successes).

As regards immediate suture, flavine and ether come next (86 and 84 per cent of successes), then soap and B.I.P.P. (about 76 per cent). No particular importance can, we think, be attached to these figures.

Regarding delayed suture, the figures, as far as they go, show a decided superiority

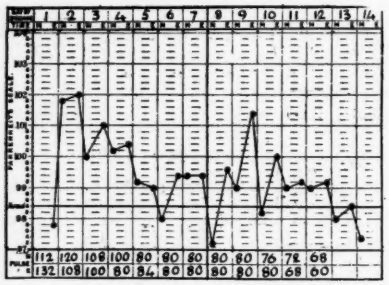


FIG. 96.—DELAYED PRIMARY SUTURE (FLAVINE); AMPUTATION OF THIGH. Shell wounds both lower limbs; on left side severe compound fractured femur and compound fractured tibia, with divided posterior tibial artery; on right side compound fractured tibia. Amputation through junction of upper and middle third of left thigh by long antero-external and short postero-internal flaps; wound packed with flavine gauze and left open; right leg, wounds excised and left open. Suture of amputation wound on third day. Complete healing; good painless stump three weeks later. Right leg left to granulate owing to loss of skin.

INFECTION: *Anaerobic*, gas-forming bacilli; *aerobic*, bacilli and short non-hæmolytic streptococci.

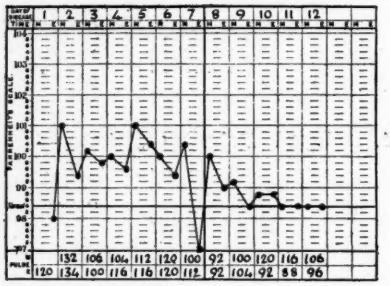


FIG. 97.—DELAYED SUTURE; COMPOUND FRACTURED HUMERUS; AMPUTATION OF THIGH; THROUGH-AND-THROUGH WOUND BUTTOCK. Shell wounds arm—compound fractured humerus; knee—joint shattered; and buttock. Excision of wound in arm, cleaning of fracture; amputation through knee-joint; both wounds left open and packed with flavine gauze; excision of buttock wound, left open with B.I.P.P. pack. Third day, re-amputation of thigh, lower third; suture. Fifth day, arm and buttock wounds sutured. Complete healing.

INFECTION: Arm—negative. Leg—*Anaerobic*, gas-forming bacilli; *aerobic*, hæmolytic streptococci and bacilli. Buttock—no culture.

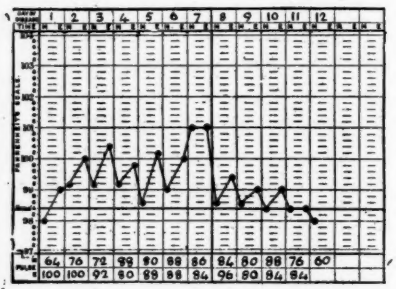


FIG. 98.—DELAYED SUTURE; COMPOUND FRACTURED TIBIA AND ULNA. Shell wounds of arm and leg; compound fracture of tibia and ulna; wounds excised and left open with B.I.P.P. pack; arm sutured on fifth day, leg on 7th day; complete healing.

INFECTION: *Anaerobic*, gas-forming bacilli; *aerobic*, non-hæmolytic streptococci.

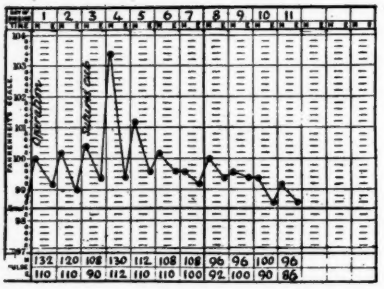


FIG. 99.—DELAYED SUTURE; SYME'S AMPUTATION. Bullet wound foot; comminution of tarsal bones; Syme's amputation; wound left open (B.I.P.P.); sutured third day; healing by first intention; excellent stump.

INFECTION: *Anaerobic*, cocci; *aerobic*, staphylococci and non-hæmolytic streptococci.

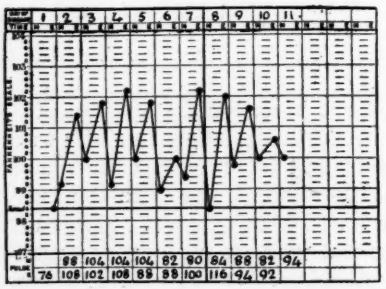


FIG. 100.—FAILURE OF PRIMARY SUTURE. Shell wound, through-and-through, of right leg, with explosive exit; excised and sutured (ether); complete failure, all sutures removed on third day.

INFECTION: *Aerobic*, long-chained hæmolytic streptococci; *anaerobic*, present.

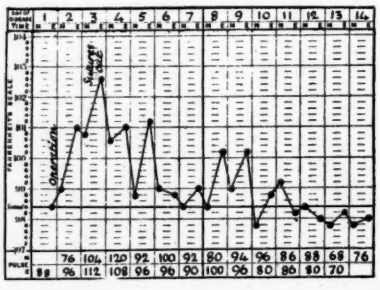


FIG. 101.—FAILURE OF PRIMARY SUTURE. Small shel wound right thigh; wound excised completely with foreign body in it (ether); complete failure, all sutures taken out on third day.

INFECTION: Long-chained hæmolytic streptococci.

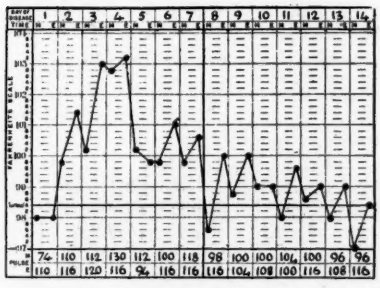


FIG. 102.—FAILURE OF PRIMARY SUTURE; STREPTOCOCCAL INFECTION OF KNEE-JOINT. Bullet wound over head of right fibula; no evidence, *x*-ray or otherwise, of communication with knee-joint; wound excised, with bullet, and sutured without antiseptic. Culture report, infection by hæmolytic streptococcus. Wound opened up immediately. Third day, effusion into knee-joint; fluid withdrawn by syringe contained hæmolytic streptococci. Fourth day, joint opened by separate incision, washed out with flavine, and sutured. Recovery; superficial suppuration in operation wound.

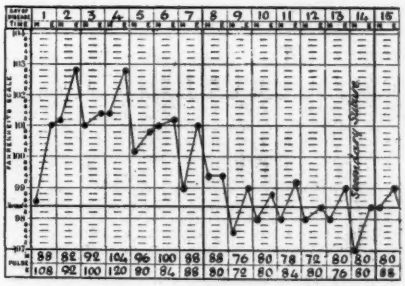


FIG. 103.—FAILURE OF PRIMARY SUTURE; SUBSEQUENT SUCCESSFUL SECONDARY SUTURE. Through-and-through wound of thigh, with extensive laceration of hamstrings and exposure of sciatic nerve; track excised as far as possible, anterior wound sutured, posterior wound left open; suppuration, removal of stitches on third day, treated as an open wound with B.I.P.P.; sutured on fourteenth day; complete healing.

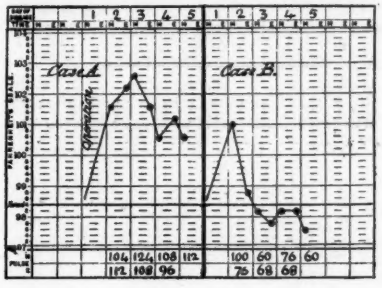
INFECTION: *Anaerobic*, gas-forming bacilli; *aerobic*, bacilli, streptococci (non-hæmolytic).

FIG. 104.—CONTRAST OF WOUND INFECTED BY HÆMOLYTIC STREPTOCOCCUS WITH NON-INFECTED WOUND.

Case A.—Through-and-through wound thigh; excised and sutured (flavine).

Case B.—Through-and-through bullet wound forearm, compound fracture ulna; excised and sutured (soap).

The condition of these two patients on the morning following operation was almost identical as regards temperature and pulse; both were in pain, both were sweating and feeling ill. The culture from *A* showing hæmolytic streptococci, his wounds were at once opened and found to be acutely septic. *B's* culture being reported negative, the wound was not even dressed; result, healing by first intention.



over the results given by immediate suture. The explanation of this will be referred to under "Bacteriology in Relation to Results."

6. **Compound Fractures treated by Suture.**—Of compound fractures, 71 have been sutured either immediately or after the lapse of a few days.

BONE	IMMEDIATE SUTURE			DELAYED SUTURE		
	Total	Success	Failure	Total	Success	Failure
Upper Extremity						
Humerus	4	3	1	8	7	1
Elbow (humerus and ulna)	2	1	1	—	—	—
Ulna	2	1	1	3	3	—
Radius	2	1	1	2	2	—
Metacarpus	2	2	—	2	1	1
Lower Extremity						
Femur	9	3	6	1	—	1
Tibia and Fibula ..	2	1	1	1	1 (partial)	—
Tibia	9	7	2	6	6	—
Fibula	2	2	—	3	3	—
Patella	1	1	—	—	—	—
Tarsus	2	2	—	3	3	—
Metatarsus	—	—	—	4	4	—
Phalanges of toes ..	—	—	—	1	1	—
Totals ..	37	24 (65 per cent)	13 (35 per cent)	34	31 (90 per cent)	3 (10 per cent)

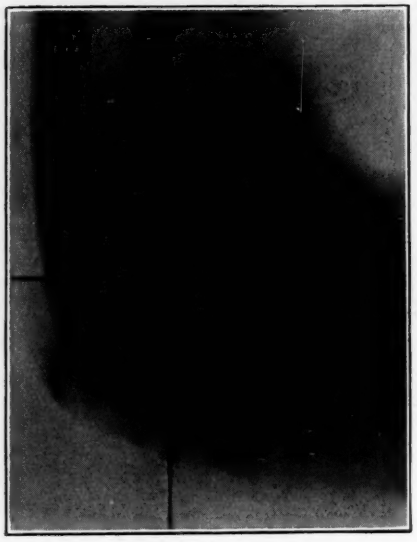


FIG. 105.—Fracture of humerus and ulna; piece of metal in elbow-joint partly embedded in ulna. Primary suture (B.I.P.P.). Healed by first intention.

FIG. 106.—Comminution of humerus. Primary suture (B.I.P.P.). Healed by first intention.

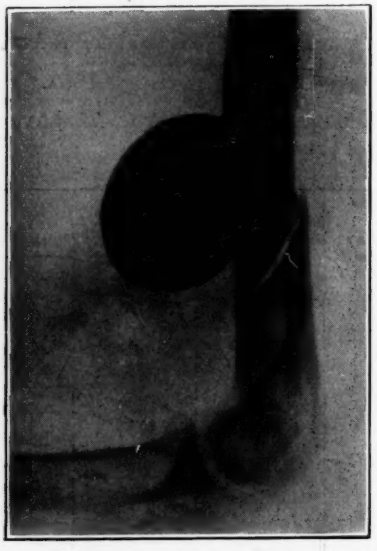


FIG. 107.—Humerus fractured by impact of large fragment of shell which entered forearm and passed into upper arm. Primary suture (B.I.P.P.). Healed by first intention

FIG. 108.—Comminution of second metatarsal. Delayed suture (B.I.P.P.). Complete healing.

7. Wounds of Joints.—

Elbow.—2 cases.

Both these were compound fractures of the humerus and ulna involving the joint: both were treated by primary suture—one healed by first intention, the other suppurated, but the patient left the C.C.S. in good condition with his wound granulating.

Ankle.—3 cases.

a. Through-and-through wound involving the ankle-joint—compound fracture of astragalus and division of the tibialis anticus and extensor longus hallucis tendons; suture of tendons and immediate closure of wound; primary union; good movement of joint.

b. Through-and-through wound involving the ankle-joint—compound fracture of astragalus; delayed suture; healing per primam; good movement of the joint.

c. Compound fracture of the lower end of the tibia involving joint; immediate suture; primary union.

Knee.—17 cases.

a. Fracture of one or more bones entering into the joint, 11 cases. These were treated by immediate suture: 6 were completely successful; 5 suppurated—amongst the latter 3 recovered without loss of limb, and 2 were amputated. One of the amputation cases died of shock and toxæmia from an acute spreading streptococcal infection of the intermuscular planes of the thigh.

b. Without fracture, 6 cases. Of these, 5 were treated by immediate suture, including one in which the patella was divided vertically in order to remove a piece of metal lying in the intercondyloid space behind the crucial ligaments; all these healed by first intention. One case in which there was extensive gas infiltration of the muscles of the thigh was treated by suture of the capsule, the external wound being left open. Sloughing of the sutured capsule took place after some days, allowing infection to spread into the joint; amputation became necessary, after which a good recovery took place.

8. Amputations.—

Immediate Suture.—6 cases.

Thigh 2; leg 2; toes 1; fingers 1. Of these cases, 4 healed per primam, and 2 were failures (1 thigh and 1 leg).

Delayed Suture.—17 cases.

Of these, 12 healed completely by first intention, and 5 with slight suppuration; none failed.

Healed by primary union completely.		*Healed with slight suppuration.*	
Thigh by musculo-cutaneous flaps	4	Thigh	2
Carden	2	Leg	1
Stokes-Gritti	1	Syme	1
Leg	3	Arm	1
Syme	1		
Forearm	1	Total	5
Total	12		

9. Deaths amongst Patients on Research List.—

Cases Sutured.

1. Compound fractured femur; anterior wound partly sutured; posterior wound left widely open: acute gas infection.

2. Compound fracture of the inner condyle of femur and tuberosity of tibia involving the knee-joint; suture; acute infection by hæmolytic streptococci; amputation; death from shock and toxæmia.

3. Shell wound of thigh exposing the femoral vessels; cleaned and left open; partial delayed suture on seventh day; secondary hæmorrhage; amputation; death from shock.

Cases not Sutured.

1. Comminuted fracture of left leg, and multiple wounds; amputation; death from shock.

2. Gunshot wound of thigh; excised; while coming round from the anæsthetic

FIG. 109.—Comminuted fracture of tibia; foreign body embedded in fracture. Delayed suture (B.I.P.P.). Complete healing.

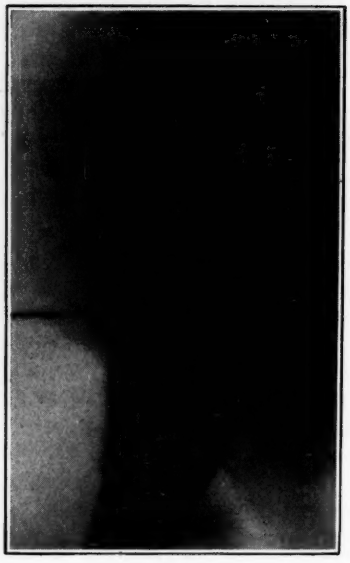


FIG. 110.—Comminuted fracture of humerus. Delayed suture (flavine). Complete healing.

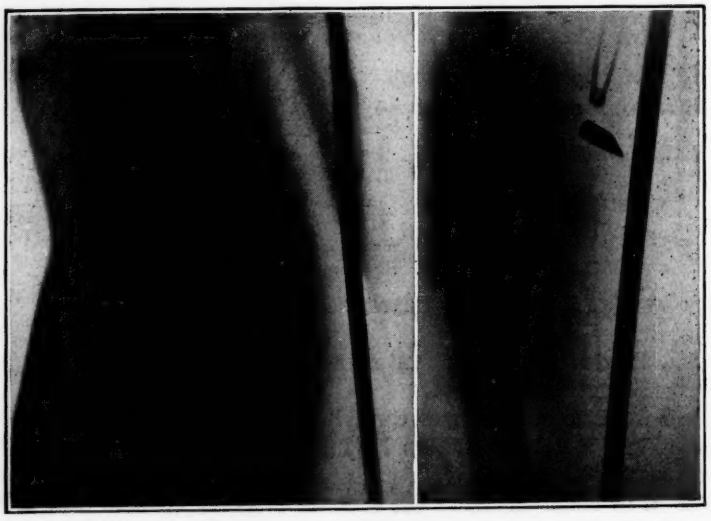


FIG. 111.—Femur fractured by bullet. Missile removed; wound sutured without antiseptic; track not touched. Healed by first intention. Bone well united without shortening in five weeks.

patient vomited and inhaled a large quantity of meat into his trachea; immediate tracheotomy; death six hours later from epileptiform convulsions; post-mortem revealed collapse of both lungs.

3. Shattered knee-joint and multiple wounds; transfused with blood twice; amputation; wounds infected with hæmolytic streptococci; death after three weeks from general streptococcal infection.

4. Compound fracture of femur; wound excised and left open; infection by hæmolytic streptococci; death from septicæmia.

10. **Bacteriology in Relation to Results.**—Of 224 wounds sutured primarily, cultures were made in 215. Of the latter, 21 (9·7 per cent) were negative; all these healed completely by first intention. The remaining 194 (90·3 per cent) were infected with anaerobes, streptococci, or other organisms mentioned in the bacteriologists' report.

The relationship of the individual organisms to success or failure is in most cases impossible to determine exactly, as the infection is generally mixed. In the 194 infected wounds treated by immediate suture, anaerobes occurred in 119 (61·3 per cent), non-hæmolytic streptococci in 62 (32·4 per cent), hæmolytic streptococci in 20 (10·3 per cent), and other organisms in 95 (48·9 per cent).

Infection	No. of Wounds	Healed by Primary Union	Failed
Anaerobes	119	88 (73·9 per cent)	31 (26·1 per cent)
Non-hæmolytic streptococci ..	62	44 (70·9 per cent)	18 (29·1 per cent)
Hæmolytic streptococci	20	1 (5·0 per cent)	19 (95·0 per cent)
Other organisms	95	64 (67·2 per cent)	31 (32·8 per cent)

The general conclusion to be drawn from these figures is that wounds infected by the hæmolytic streptococcus nearly always become septic, while a large proportion of wounds infected in other ways heal by first intention. Failure took place in only one case of primary suture which was infected by anaerobes alone; in this case a muscle flap used for filling a bone cavity sloughed and a gaseous abscess developed in the wound.

Streptococcal Infection.—Only one case infected by hæmolytic streptococci (a small wound penetrating the knee-joint without damage to bone) healed by first intention; all the rest suppurated, many of them violently and with severe constitutional disturbance. Infections by non-hæmolytic streptococci as a general rule appear to be less virulent. As shown by the above figures, a considerable proportion of wounds containing these organisms healed by first intention. When failure occurs, the suppuration is usually milder than that characteristic of the hæmolytic streptococcus. Sometimes, however, the non-hæmolytic streptococcus, in association with other organisms, appears to set up sepsis of a very severe type. Although only one case infected by these streptococci alone has failed to heal by first intention, our clinical experience leads us to look on their presence with suspicion when anaerobes and other bacteria accompany them.

Delayed Primary Suture.—The 4 cases of delayed suture which failed were infected as follows:—

1 wound with anaerobes and non-hæmolytic streptococci
1 „ „ „ „ hæmolytic streptococci
2 wounds „ „ „ staphylococci

The advantage which delayed suture offers as compared with immediate suture depends on the knowledge of virulent infection gained during the interval while the wound is open. Even if a bacteriological examination has not been made, the appearance of a virulently infected wound when first dressed forty-eight or seventy-two hours after operation is usually distinctive, and it is not sutured. In this way the proportion of failures after delayed suture should be reduced to a very small percentage.

While no antiseptic which we have tried, either in open or closed wounds, appears to us to have any appreciable effect on the growth of the hæmolytic streptococcus, the

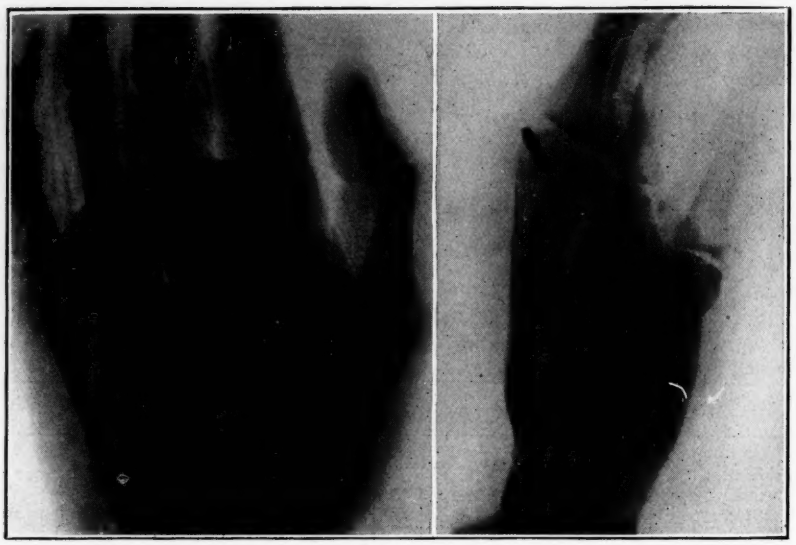


FIG. 112.—Fracture of head and splitting of shaft of third metacarpal. Primary suture (soap). Healed by first intention.

FIG. 113.—Compound fracture of fourth and fifth metatarsals, external cuneiform, and cuboid. Delayed suture (B.I.P.P.). Complete healing.

following statement of the results of the use of flavine points to the probability that chemical antiseptics, when applied to the surface of open wounds infected with bacteria of less virulence, may fulfil a useful function.

11. **Use of Flavine in Delayed Suture.**—In 35 cases in which the wound was packed with gauze soaked in flavine solution (1–1000), and in which the original culture showed the presence of infection (other than hæmolytic streptococci), smears taken from the wound on the second or third day prior to suture were examined, and in 31 cases no organisms could be found. It appears probable, therefore, that flavine used in this way acts definitely as a germicide. We have unfortunately no control experiments on wounds left open and packed with gauze without the addition of any antiseptic.

We have found it advisable to discontinue the use of flavine solution after four or five days, as wounds treated continuously with this substance for longer periods tend to become covered with a layer of coagulated lymph or necrosed tissue in which bacterial growth appears to flourish.

Used in the early stages and for a limited time, flavine, in our experience, gives satisfactory results.

12. **Sterility of Bullet Tracks.**—We have found that the narrow track of a bullet which has passed into or through a limb, without producing an 'explosive' effect by spinning or striking a bone, is usually sterile, and that operation on wounds of this type is unnecessary.

Further, we have found that where the entry wound and part of the track are clean and narrow, while the exit is lacerated, only the exit wound is likely to be infected. In such a case operation should be limited to a careful cleansing of the exit wound, damaged tissue being removed only till the orifice of the narrow track is exposed. A culture taken by introducing a swab into the latter will probably be negative, and this part of the wound need not be interfered with.

III. BACTERIOLOGICAL REPORT.

By Captain Adrian Stokes and Major W. H. Tytler.

Collection of Material.—The material was collected from the wounds at the time of operation, after the skin surface had been cleansed with salt solution, but before any antiseptic had been applied, and before the interior of the wound had been disturbed. A guarded swab was used, made by placing a long stout wire wrapped at the end with cotton-wool in the ordinary way inside a narrow glass tube open at both ends and about half the length of the swab wire. The whole was sterilized in a plugged test-tube (see *Fig.* 81). For use, the tube, with the swab still inside, was introduced into the depth of the wound, avoiding contamination from the wound edges, the swab was pushed out of the tube, thoroughly rubbed about in the wound, and again withdrawn within the tube before removing the latter from the wound. The tube and swab were replaced in the test-tube and sent to the laboratory.

Cultural Methods.—After flaming the distal end of the guard tube, the swab was pushed out, and first streaked in several lines over the surface of a blood-agar plate. It was then thoroughly washed out in a test-tube containing about 3 c.c. of sterile salt solution. From this emulsion aerobic and anaerobic cultures were made. Whenever circumstances permitted, the cultures were set up immediately on the receipt of the infected swab.

Aerobic Cultures.—In addition to the blood-plate, about ½ c.c. of the emulsion from the swab was inoculated with a pipette into a trypsin-broth tube, the remainder being used for anaerobic cultures. The object of the blood-plate was to obtain early evidence of the presence of hæmolytic streptococci. The broth culture and plate were examined after sixteen to twenty hours' incubation. In the great majority of cultures from which a hæmolytic streptococcus was obtained, the presence of this organism was definitely evident on examination of the original blood-plate. The same was true in less degree of non-hæmolytic streptococci, although there was some danger of mistaking other organisms—particularly *M. tetragenes*—for such streptococci Smears were made from the

FIG. 114.—Severe comminuted fracture of lower end of femur and patella. Removal of patella and loose fragments from condyles; immediate suture (B.I.P.P.). Healed by first intention, with the exception of a slight local suppuration where a hæmatoma had to be evacuated.

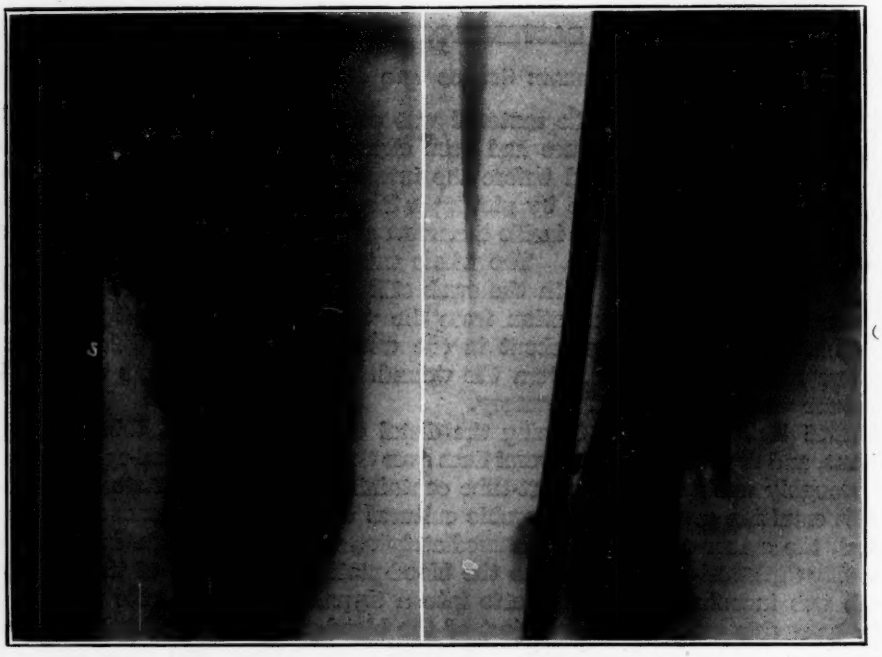


FIG. 115.—Severe fracture of femur into knee-joint, which was widely opened. Primary suture (without antiseptic). The limb becoming distended with gas, the sutures were removed from the posterior wound after 24 hours, and a pack of gauze, soaked in flavine, was inserted; 48 hours subsequently this wound was again sutured. Staphylococcal infection of the posterior wound took place, causing suppuration. The anterior wound remained closed.

N.B.—In this case, and in that shown in *Fig.* 114, the choice lay between closure of the wound and amputation. We have reason to believe that sometimes a limb may be saved by early suture of the wound, which under the usual open treatment would certainly be lost.

broth cultures, and the organisms present, as well as those on the plate whose nature was evident, were reported to the surgeons. In most cases, and in all cases where the broth showed streptococci and the plate none, the broth culture was plated on blood-agar. In about half of all cultures the broth was again examined after two days' growth, but in only one instance was a streptococcus (in this case hæmolytic) found which had not been evident at the first examination.

In all cultures the presence or absence of streptococci, and the nature of those present, were determined, and the other aerobes present were also recorded in so far as their nature was evident from the plate and smear. In a consecutive series of 165 wounds the aerobic cultures were worked out as fully as possible, each type of colony on the original plate and on the plate from the broth culture being picked off and determined within the limits of the classification given in *Table* 4.

Anaerobic Cultures.—One to two c.c. of the emulsion made from the swab was planted on Robertson's meat medium. After incubation for sixteen to twenty-four hours the culture was examined microscopically after noting the presence or absence of gas production. The result was reported as "bacilli with gas," "bacilli with no gas," and so on. Those showing bacilli with gas formation were regarded as positive for anaerobes, and the total figures given in *Tables* 2 and 3 are made up on this basis. The bacilli with no gas formation were regarded, after some experience, as aerobes, even where no growth occurred in aerobic culture. Usually, in such cases, aerobic bacilli were obtained on the original plate or on the plate from the broth culture. About two-thirds of all cultures which showed gas formation were further investigated as follows :—

After the first examination, a subculture was made in bulk on milk and an anaerobic plate was made. After experience gained in the isolation of fifteen strains of *B. Welchii* by repeated plating and rapid passage through fluid media, it was possible to recognize with a considerable degree of certainty the colonies of *B. Welchii*. The cultures recorded in *Table* 6 as containing *B. Welchii* are those which produced both typical colonies and a typical 'stormy fermentation' clotting in the milk tubes.

The positive milk cultures were then further incubated for five to seven days, heated to 80° C. for fifteen minutes, and subcultured into meat tubes, which were then incubated for three days to allow spore-bearing organisms to grow out. These subcultures were then examined and plated. After three days' incubation the plates were picked, and each type of colony was subcultured anaerobically and also aerobically to eliminate aerobic sporers.

The figures given in *Table* 6 for anaerobic sporers represent only those cultures in which the final results have been obtained up to the moment of making up the statistics. There remain a series of cultures which are still under investigation.

The percentage of spore-bearing anaerobes found is smaller than in examinations carried out at the base. The explanation of this is obviously that, in the early examination, sporers, which are more slow-growing organisms than *B. Welchii* and the saccharolytic anaerobes, have not had time to multiply sufficiently to be secured in culture.

The types of anaerobes isolated in the course of the present work include *B. Welchii*, *B. sporogenes*, *Vibrion septique*, *B. phallax*, *B. tertius*, *B. histolyticus*, *B. aerofetidus*, and several strains as yet unidentified.

Table 1.—Material Examined.

Total cases examined = 304 { of which 257 had 1 wound ; ,, ,, 37 ,, 2 wounds ; ,, ,, 6 ,, 3 ,, ; ,, ,, 4 ,, 4 ,, }

Total wounds examined = 365.

From 289 of these 1 culture only was examined
,, 51 ,, 2 cultures were examined
,, 22 ,, 3 ,, ,, ,,
,, 2 ,, 4 ,, ,, ,,
,, 1 ,, 5 ,, ,, ,,

Total specimens cultured = 470.

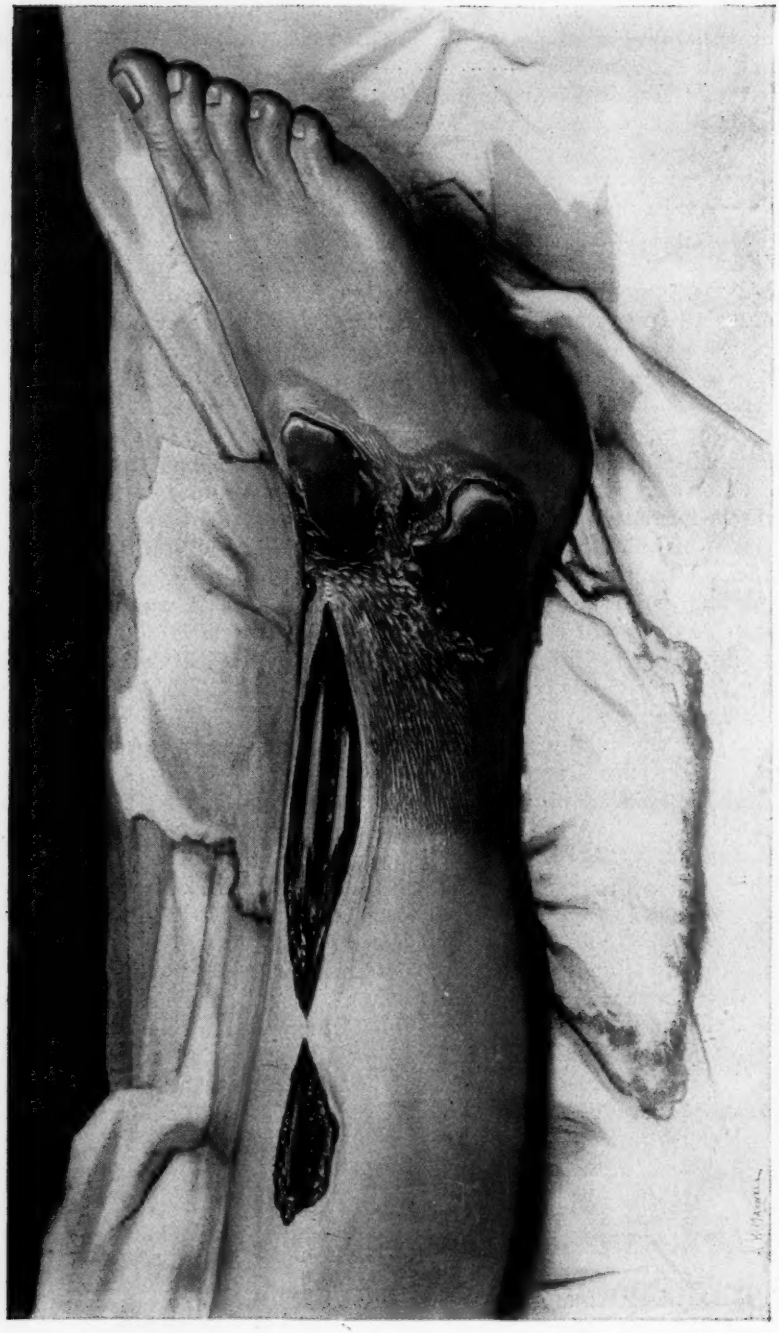


FIG. 116.—Shell wound of leg; comminuted fracture of tibia and fibula, division of anterior tibial artery. Wounds excised, cleaned, and left open. Onset of acute gas gangrene 39 hours subsequent to operation; vibrion septique found in bullæ in wound and in blood-stream.

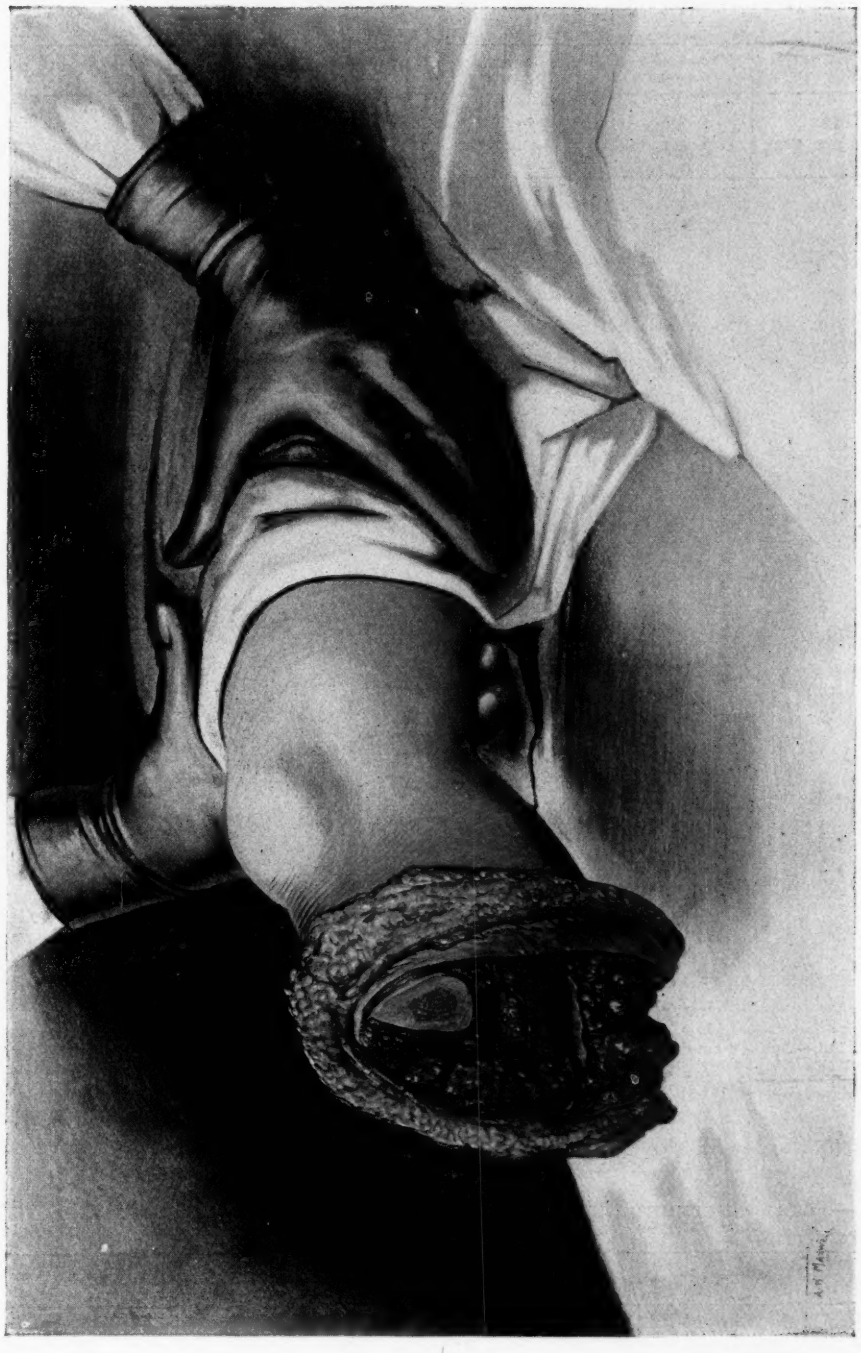


FIG. 117.—Amputation at site of election by lateral flaps for condition shown in *Fig.* 116. Four days later gangrene appeared in flaps; culture showed presence of vibrion septique. A Carden amputation was done, the flaps being left unsutured, and the wound packed with flavine gauze.

Table 2.—FIRST CULTURES EXAMINED BOTH FOR AEROBES AND ANAEROBES (343 WOUNDS).

AEROBES PRESENT	AEROBES ABSENT	ANAEROBES PRESENT	ANAEROBES ABSENT	BOTH PRESENT	BOTH ABSENT
300 87·8 per cent	43 12·2 per cent	183 53·3 per cent	160 46·7 per cent	160 46·7 per cent	26 7·6 per cent

FIG. 118.—Carden's amputation referred to in *Fig.* 117 sutured 48 hours after operation. This wound healed by first intention, with the exception of some dry gangrene of the margin of the anterior flap. Patient made an excellent recovery.

Table 3.—TOTAL CULTURES EXAMINED FOR AEROBES AND ANAEROBES RESPECTIVELY.

TOTAL CULTURES	AEROBES		TOTAL CULTURES	ANAEROBES	
	Present	Absent		Present	Absent
1st : 365	310 (85 per cent)	55 (15 per cent)	1st : 338	172 (50·9 per cent)	166 (49·1 per cent)
2nd : 76	53 (70 per cent)	23 (30 per cent)	2nd : 69	19 (27·5 per cent)	50 (72·5 per cent)
3rd : 25	21 (84 per cent)	4 (16 per cent)	3rd : 25	7 (28·0 per cent)	18 (72·0 per cent)

Table 4.—Aerobic Cultures in which as far as possible all Organisms were determined. (*Includes negative cultures occurring in the series.*)

Total Cultures	Negative		Hæmolytic Streptococci		Non-hæmolytic Streptococci		White Staphylococci		Yellow Staphylococci	
	No.	per cent	No.	per cent	No.	per cent	No.	per cent	No.	per cent
1st: 165	23	13·9	30	18·2	64	38·8	80	48·5	23	14
2nd: 60	19	31·6	13	21·6	8	13·3	18	30	9	15
3rd: 19	2	10·5	8	42·1	2	10·5	4	21	7	36·8

Total Cultures	Tetragenes		Diphtheroids		Gram-negative Cocci		Gram-negative Bacilli		Gram positive Bacilli	
	No.	per cent	No.	per cent	No.	per cent	No.	per cent	No.	per cent
1st: 165	22	13·3	12	7·2	15	9	38	23	59	35·7
2nd: 60	1	1·6	2	3·3	4	6·6	6	10	8	13·3
3rd: 19	0	—	0	—	1	5·2	5	26·3	1	5·2

Table 5.—Cultures Examined for Streptococcus.

Total Cultures	Hæmolytic Streptococci		Non-hæmolytic Streptococci		Total Streptococci	
	No.	per cent	No.	per cent	No.	per cent
1st: 365	54	14·8	104	28·6	15	43·4
2nd: 77	15	19·5	13	16·9	28	36·4
3rd: 26	19	34·6	4	15·4	23	40

Table 6.—Anaerobic Cultures showing Bacilli with Gas, examined for B. Welchii and Sporers.

Total Cultures Examined	B. Welchii		Anaerobic Sporers	
	No.	per cent	No.	per cent
102	94	92	—	—
45 (for sporers)..	—	—	21	46

OBSERVATIONS ON THE ABOVE TABLES.

Table 2.—The figures for 'aerobes present' include twelve cultures which showed bacilli with no gas production in the meat tube, but which showed no growth on the aerobic cultures. Experience justifies the view that such bacilli are nearly always aerobes.

The cultures recorded as 'anaerobes present' are those showing bacilli with gas formation in the meat tube. These figures are undoubtedly too low, as time and personnel did not permit the exhaustive examination of more than about a half of all anaerobic cultures, and the results in the remainder were those recorded after sixteen to twenty hours' incubation only.

Table 3.—The same remarks apply to these figures as to those in *Table* 2. First cultures are those taken before operation, as described above. Second cultures were usually made at the time of first dressing; in all but six cases the interval after operation was between one and seven days, with an average of three days. Third cultures were made from four to fourteen days after operation, averaging eight days.

The wounds from which second and third cultures were made were those which were left open—that is, the more serious wounds—and so the percentages, by comparison with the first cultures, which included all wounds, are much too high. The same remarks

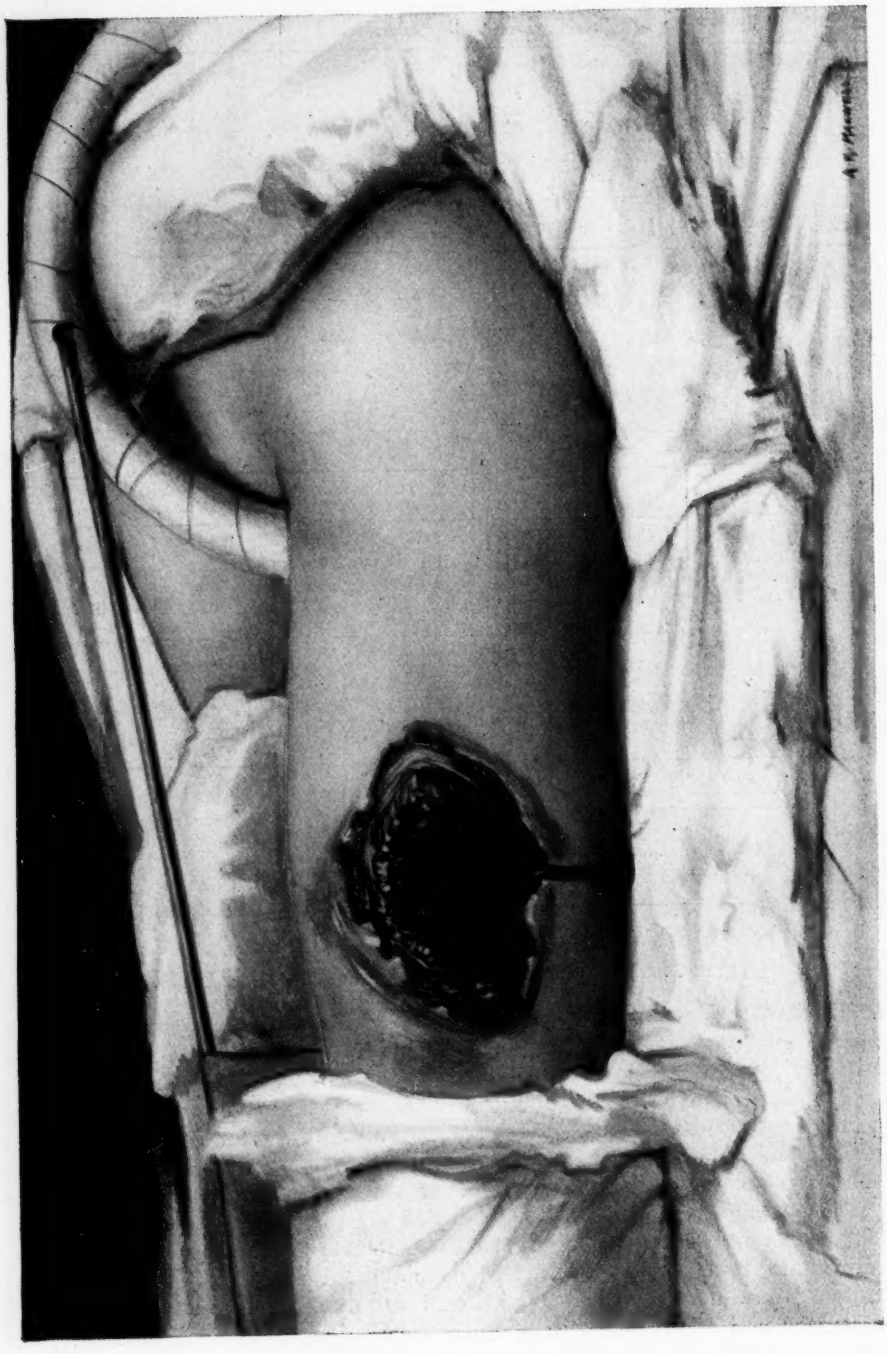


FIG. 119.—Explosive exit wound in arm caused by rifle bullet, 13 hours after infliction. Comminuted fracture of humerus.

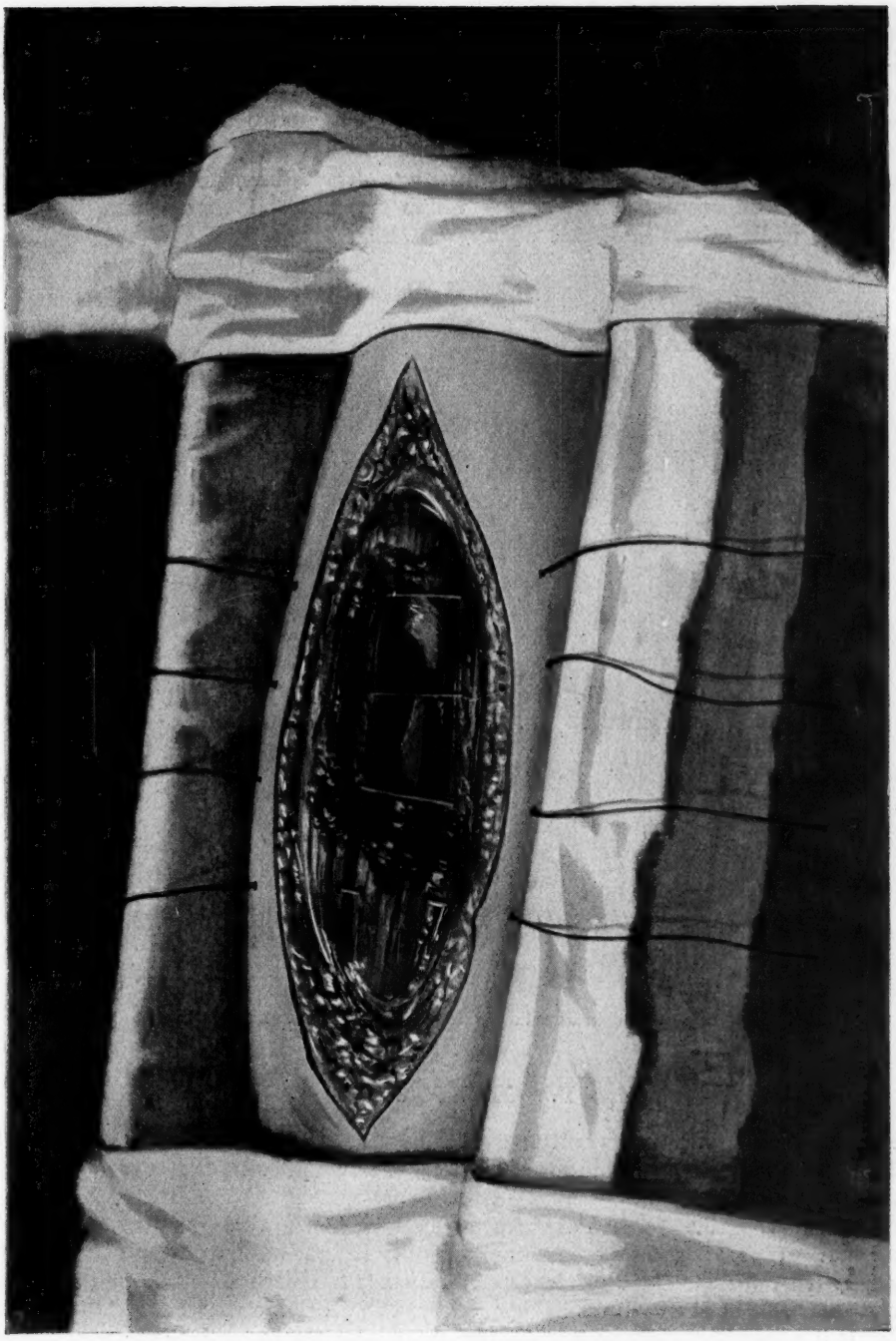


FIG. 120.—Wound shown in *Fig.* 119 after excision of damaged muscle and cleaning of the fracture, and after a further interval of 48 hours, during which it was packed with gauze soaked in soap solution. Deep sutures of 'bipped' silk in position.

apply to *Tables* 4 and 5, and particularly to the figures for hæmolytic streptococci, since wounds which were found to contain these organisms were usually opened up and further cultures made.

Table 4.—To the figures for bacilli in the first cultures must be added four cultures which showed bacilli with no gas production in the meat tube with no growth aerobically.

The figures for white staphylococci are for those cultures which remained white after twenty-four to forty-eight hours in subculture. Of a series of 100 such organisms which were further grown out over a period of a month or more, 20 per cent ultimately produced yellow pigment. The necessary correction, however, is not as great as 20 per cent, since many of the wounds from which such organisms came had already yielded yellow staphylococci, and in some of the wounds where several strains were grown out, some became yellow while others remained white.

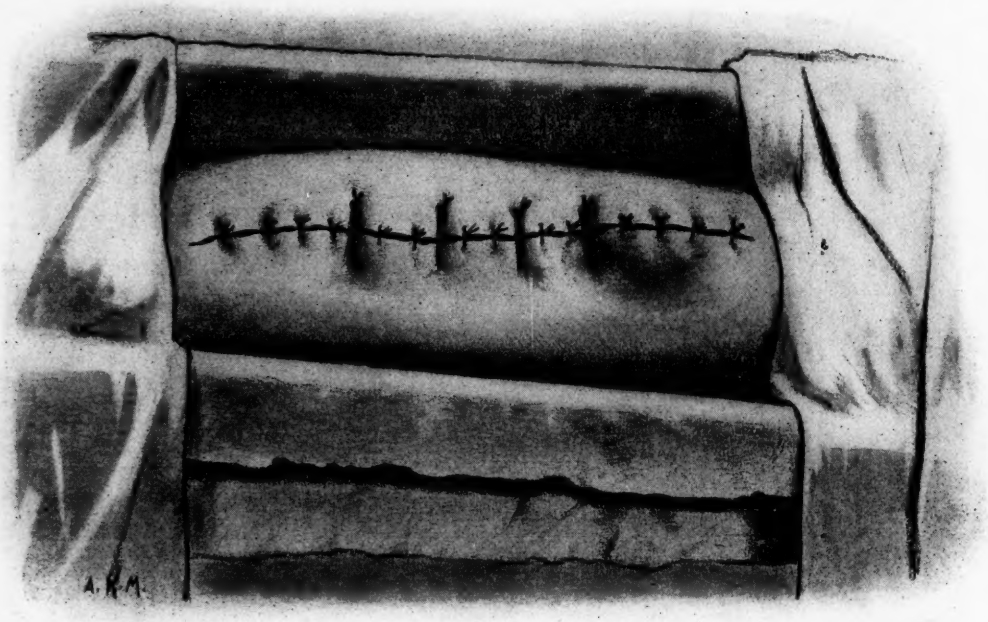


FIG. 121.—Closure of wound shown in *Fig.* 120. The wound healed by first intention.

IV. CONCLUSIONS.

The number of cases is too small to enable us to form definite conclusions on points of detail, such as the value, absolute or relative, of antiseptics in the closure of infected wounds.

We have been able to confirm fully the statement already made by French surgeons, that of the organisms commonly found in gunshot wounds the hæmolytic streptococcus is by far the most virulent. Although it has been found to be present only in about 15 per cent of the cultures in this series, yet we believe that in the later stages of open wounds it is far more common. In the absence of this organism the vast majority of wounds can be closed and made to heal by first intention, in spite of the presence of other infections.

So far we have not found that any antiseptic we have tried can be said to have any palpable effect on wounds infected by these organisms. They appear to penetrate

FIG. 122.—High-explosive shell wounds of thigh, 13 hours after infliction.

FIG. 123.—Dissection of thigh required to clear away dead and infected muscle found in wound shown in *Fig.* 122. Fourteen metallic fragments were removed from this wound by an electro-magnet (see *Fig.* 121). The infection was by hæmolytic streptococci, so that delayed primary suture could not be carried out.

FIG. 124.—Sketch from *x*-ray plate showing fragments of metal in the thigh. In case shown in *Figs.* 122, 123.

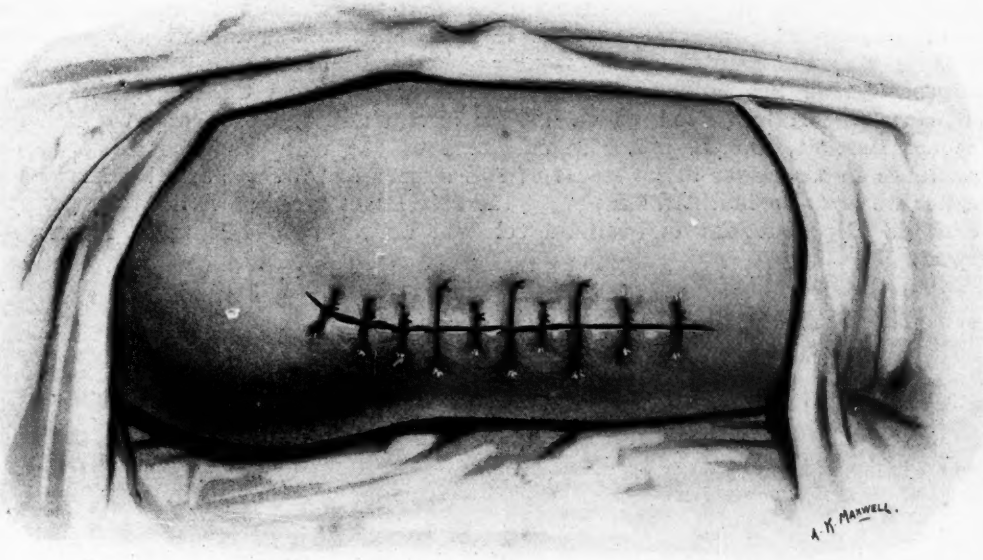


FIG. 125.—Showing suture of a wound in thigh. This wound was very septic; it was washed with ether, and packed with 'bipped' gauze for 6 days before suture was attempted. It healed by first intention.

so quickly into the tissues that it may be that no substance applied to the surface of a wound can be expected to have much effect.

The discovery of a serum which would give efficient protection against this type of infection appears to us to be a matter of such importance that we venture to hope a concentrated effort may soon be organized on a sufficiently large scale with the object of solving this problem.

Routine Bacteriological Examination.—Although the preparation of cultures from every wound to be sutured is an undoubted advantage, it is obviously impracticable if suture is to be carried out on a large scale. We believe that careful clinical observation renders routine bacteriological examination unnecessary in the average case. We suggest that in times of pressure, cultures should be taken only from deep and severe wounds, and that the examination should be limited to ascertaining the presence or absence of hæmolytic streptococci. The isolation of other bacteria, and particularly the identification of varieties of anaerobes, does not appear to be necessary in the class of wounds likely to be considered suitable for early closure.

Comparison of Immediate and Delayed Suture.—While it is evident that with careful selection of cases and efficient operation immediate suture may be counted on to meet with a large measure of success, and while immediate suture must be the operation of choice for certain classes of wounds, such as those of the head and chest and those involving joints, yet we incline to the belief that for general use in the average wound delayed suture is safer and more certain in its results.

During periods of active fighting, when cases cannot be retained for at least several days after operation, delayed suture is the only means of early closure at our disposal. This method has the advantage that the presence of virulent infection can be ascertained before the wound is closed, by clinical evidence and microscopical examination. In this way wounds with virulent infection, the majority of which if sutured would be failures, can be excluded from closure till later periods when the infection has been overcome. In the case of severe wounds, and when the operator is in the least doubt as to whether he has succeeded in efficiently removing dead and damaged tissue, delayed suture, in our opinion, should have the preference as a general rule.

In conclusion, we wish to express our thanks to the Medical Research Committee, who have supplied us with a typewriting machine and with literature; to Surgeon-General O'Keefe, who has granted us the facilities and conditions necessary for the work; to Surgeon-General Sir Anthony Bowlby, Colonel Sinclair, and Colonel Gask, consulting surgeons, who have helped us with their advice and interest; and to Lieutenant-Colonel Marriott, D.S.O., officer in command of the unit, who has given us every assistance in his power at all stages of this research. To the Medical Research Committee we are also indebted for placing the services of Sergeant A. K. Maxwell at our disposal. Reproductions of beautiful coloured drawings by this artist illustrate our report.

ACUTE DILATATION OF THE STOMACH.

By WILLIAM DOOLIN, Dublin.

Acute dilatation of the stomach has long been a source of mystery to pathologist and clinician alike. Hilton Fagge, in 1873, published the earliest authoritative account of the condition in English. Prior to that date, isolated cases of a similar condition had been recorded by Rokitanski (1842), Miller and Humby (1853), Bennett (1856), and Wilks (1857). It was recognized and well described by Brinton in his *Lectures on Diseases of the Stomach*, in 1859. In 1899 Albrecht could only find 18 cases recorded in the general literature, and in 1902 Campbell Thomson published an analysis of 44 collected cases. Within the past ten years important references to this question have been published in America by Conner (1907), Laffer (1908), Borchgrevink (1913), and Lee (1916); in France by Delangénière (1909), Lardennois (1910), and Mathieu (1911); and in Germany by Braun and Seidel (1907), Axhausen (1909), v. Haberer (1913) and Linke (1914). English medical and surgical literature during the same period, save for the published cases of Box and Wallace (1911), has been surprisingly reticent on the subject.

The first case of the kind which I met with was in 1910, when house surgeon at St. Vincent's Hospital. The patient was a stout woman in the middle forties, and Professor Alfred Smith was operating for a large myoma uteri. As he was about to close the abdomen, the patient showed signs of respiratory distress, the abdominal walls began to bulge, and the lower border of the stomach appeared in the upper margin of the wound. We noticed at the time that the gastro-epiploic veins and their tributaries were enormously engorged. The condition was immediately recognized, and a stomach tube promptly passed, whereupon a large quantity of gas was brought off, followed by a fair quantity of fluid. This relieved the condition, and the stomach receded into the epigastrium. The tube was left *in situ*, the abdomen closed, and the patient brought back to bed and placed on her right side. There was no recurrence of the dilatation, and the patient made an uneventful recovery.

My second case presented itself under widely different circumstances.

Mrs. J. W., age 19, was admitted to St. Vincent's Hospital late at night on Oct. 10, 1917, as being a case of acute intestinal obstruction. Temperature on admission 97·2°; pulse 148; respirations 24. Patient was very collapsed, with drawn, anxious facies, and heavy rings under the eyes; pupils moderately dilated.

Previous History.—On June 30, 1917, patient gave birth to a premature (7 months) child; labour was normal, but later she developed puerperal sepsis, on which account she was detained for ten weeks in the maternity hospital. She then went home, very weak, and lay for a further three weeks confined to bed.

Present Illness.—On Oct. 8, after "a good dinner" she was suddenly seized with violent epigastric pain; seven or eight hours later she commenced vomiting, which continued incessantly during the night. Her bowels moved naturally once before vomiting set in. The next day a doctor was sent for, who administered an enema, which gave a good result; there was no cessation, however, of pain or vomiting, which continued unabated. The following day vomiting continued, large quantities of yellowish-green fluid, sour to the taste, but of inoffensive odour, coming up incessantly, despite the fact that nothing had passed her lips for thirty-six hours. She was then sent to hospital.

On Admission.—Condition one of extreme exhaustion. The abdomen, which moved freely on respiration, was enormously distended, with a marked prominence below and to the left of the umbilicus. This protrusion was exquisitely tender to the touch, and highly tympanitic. The tympanitic note extended practically to the left nipple line above, out to the flank, and down to a point two finger-breadths above the left Poupart line; it then 'elbowed' sharply upwards to just above and to the right of the umbilicus. Vomiting had ceased shortly after admission, which I took to be of bad omen. During my examination, which lasted nearly half an hour, there were three distinct crises of visible peristalsis, the waves passing from the left above, downwards and to the right: as they passed, the patient moaned with the intensity of the cramping

pain. Succusion splashing was very marked below the umbilicus. Patient remarked she had not passed urine since the previous night; a catheter was passed and 8 ounces of urine were withdrawn. (Urine analysis showed: density 1024; acid; albumin and sugar absent; no casts; no blood-cells; calcium oxalate crystals were present in abundance, and a large proportion of amorphous urates.) Thirst was not complained of.

I thought the patient was *in extremis*. We had the foot of her bed raised on a chair, and she was placed prone on her face, with a large pillow beneath the pelvis. This, she stated, gave her distinct relief from the pain. Nutrient enemata with brandy were administered every three hours during the night, and subcutaneous saline was given under the breasts.

The next morning (Oct. 11) I found the ventral position had given her complete relief from pain. Her facial appearance had improved beyond recognition. Temperature 97·6°; pulse 84; respirations 20. No vomiting during the night. The stomach had receded to about half its size of the previous night. Eighteen ounces of urine were passed in twenty-four hours.

Oct. 12.—Stomach distention quite receded. No pain. No vomiting. Temperature 98°; pulse 78; respirations 20. Patient very hungry; allowed chicken tea, cautiously, in sips. Twenty-two ounces of urine passed in twenty-four hours.

Oct. 30.—After an uneventful recovery, patient went home.

I can ascribe this patient's recovery solely to the use of the prone position. She was well-nigh *in extremis* on admission, so much so that I was afraid to subject her to the physical strain of washing out her stomach. And yet, after twelve hours in the prone position, her condition of extreme collapse was over, her pulse had come down from 148 to 84, and was of good volume, the distressed facies had quite disappeared, she presented a smiling countenance, informed me the pain was gone, and declared herself, notwithstanding the still evident degree of gastric distention, as being quite comfortable.

Had I not had the fortune to have read Borchgrevink's valuable paper previously, and to have recollected his emphatic assertion of the value of treatment by the prone position, I am convinced that the patient would not be alive to-day.

On consulting the usual English text-books, I was very disappointed at the meagre amount of information obtainable concerning this unusual malady and its treatment. The value of the prone position, as borne out by Continental and American authors, does not seem as yet to have obtained adequate recognition in English surgical literature. Thomson and Miles (1915) do not even mention it, but recommend gastrostomy if lavage be unsuccessful. Douglas (*Diseases of the Abdomen*, 1910) recommends lavage, but gives no mention of postural treatment. Paterson (*Diseases of the Stomach*, 1913) advocates lavage and the knee-elbow position. Moynihan (*Abdominal Operations*, 1914) is the sole advocate of the prone position and early lavage. Choyce (*System of Surgery*, 1915) barely refers to postural treatment, recommends lavage, and states that operation is inadvisable. A search through the available literature at my disposal has led me to the conclusion that this malady is by no means infrequent; and that its high mortality may be accounted for by want of early recognition, and by an insufficient understanding of its etiology, leading to injudicious methods of treatment.

The 188 cases which I have succeeded in collecting from available sources may be divided into two large groups:—

1. Where the condition arises as an unexpected and unwelcome sequela to operation.
2. Where the condition arises without any prior operative interference.

Of the 188 cases, 133 (nearly 69 per cent) occurred after operation. This post-operative group is of exceeding interest; 96 of these cases were abdominal operations, of which gynecological operations head the list with 40 cases, operations on the gall-bladder come next with 20, operations on the stomach and duodenum 18, appendicectomy 11, and herniotomy 5. Of the extra-abdominal operations, the kidney gives 7 cases, the thorax 6, the extremities 13, and the face 1.

The group of non-operative cases is well worthy of investigation. Here several sub-groups may be defined. A fairly large number of cases has been reported where the occurrence of the condition was attributed by the observer to intake of excessive quantities of food or drink (dilatio ex ingestis). In another specialized sub-group of 10 cases, the condition was associated with spinal deformity (Wichern, Kelling, Perry and Shaw, Buzzard, Kirch, Kausch, Willett, Neck, Hanssen, Bollag). The condition has also arisen

during the course of acute or long-continued febrile disturbances : pneumonia, for instance, has 4 cases to its credit (Box and Wallace, Campbell Thomson, Herrick, and Leonhardt), as has also typhoid (Brinton (2 cases), Wichern, and Baümler). It has occurred once during the course of phthisis (Neck), diabetes mellitus (Box and Wallace), and sciatica (Baümler). Injury to the abdominal wall has been followed by the development of the condition in 3 cases (Tuffier, Appel, Box and Wallace). Confinement was complicated by acute gastric distention in 4 cases (Campbell Thomson, Laffer, Audebert, and Rice), and Cæsarean section in 2 (Theilhaber and Audebert). Finally, we have an extremely remarkable group where the condition arose suddenly in perfect health, without any explanation whatever ; in one case it is recorded that the condition started " in a hearty laugh."

Over 60 per cent of the recorded cases occurred in women. It may arise at any age, but is most frequent between 20 and 40 years. The youngest case was that of a breast-fed child nine months old, found dead two hours after suckling ; there was no vomiting, yet at autopsy the stomach was " as large as a football " (Belilios). Cooper has recorded an even more rapid death in a child of eleven months, under very similar circumstances. The oldest case was that of a man, age 86, who was admitted to hospital with an intra-capsular fracture of the neck of the femur, and who died within half an hour of taking a glass of milk ; the condition was diagnosed at autopsy (Moore).

In the post-operative group, all the operations were carried out under general narcosis, with but two exceptions ; one case occurred after spinal analgesia with novocain (Taddei), and one after a herniotomy carried out under a local anæsthetic (Lyle).

ETIOLOGY.

Efforts to explain the genesis of this condition have led to a riot of theories. The very multiplicity of titles* given to the syndrome is in itself an evidence of the numerous hypotheses which have been advanced from time to time in explanation of the origin of this mysterious malady. An 'individual predisposition' has been alleged by some writers who have had the very unpleasant experience of meeting this complication in successive operations upon the same patient ; it is obviously an unsatisfactory explanation. Riedel has advanced a theory of serous infiltration of the stomach wall with subsequent dilatation, which, however, has failed to obtain support from other observers. The condition has been ascribed to adrenal incompetency by Arcangeli,† and to a general insufficiency of the chromaffin system by Kuru.† Rokitanski first definitely ascribed the dilatation to compression of the horizontal portion of the duodenum by the root of the mesentery. In this explanation he had the support of subsequent observers such as Kundrat (1891), Albrecht (1899), and Müller (1900). The last writer ingeniously drew attention to one particular class of case not infrequently followed by this distressing complication, viz., where the pelvis or lower abdomen has been occupied for a long period of time by a large ovarian cyst or uterine tumour which, growing up out of the pelvis, has crowded the intestines into the upper abdomen ; after removal of the tumour, the coils of gut sink down into the now empty pelvis, and so drag upon the superior mesenteric artery as to compress the duodenum at its crossing.

This theory, which we may call that of ' primary duodenal obstruction,' for long held the field, and even to-day has some supporters. A dilated stomach and a duodenum partly or completely obstructed are two undeniable anatomical facts frequently found on the post-mortem table. Which is the primary phenomenon, however, and which the secondary ? It is well-nigh impossible to prove to everyone's satisfaction that a primary occlusion of the duodenum does not, or cannot, cause an acute dilatation of the stomach.

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* It has been variously described as " Acute Dilatation of the Stomach," " Gastro-mesenteric Ileus," " Acute Gastroduodenal Atony," " Mesenteriale Darmverschluss," " Traumatische Magenerweiterung," " Paralysie Stomacale Aiguë Post-opératoire," " Gastro-enteroplegia," " Acute Gastrosuccorrhœa," and " Acute Gastric Motor Insufficiency."

† Quoted by Lee.

The theory at first sight is easily acceptable, as we are all familiar with the dilated bowel above the site of constriction in mechanical ileus. Nevertheless, we find on deeper investigation a mass of evidence, direct and indirect, which has led the great majority of recent writers to discard this theory. The first argument that strikes one against Müller's hypothesis is the extreme rarity of such an occurrence after child-birth; of the 188 cases mentioned above, only 4 took place as a postpartum complication. The extreme rapidity with which the stomach may dilate does not point to a mechanical occlusion of the duodenum as being the primary cause; in my first case the stomach swelled up to a truly alarming size within a few minutes, and cases of an almost identical character have been recorded by others (Luckett, Moorehead, Mayoral and Richardson). It seems incredible that a mechanical blockage of the duodenum could break down the resistance of the pylorus and cause an enormous gastric distention in so short a space of time. In high jejunal obstruction, the nearest clinical parallel—as observed by Borchgrevink, Axhausen, Wilms, and others—this great dilatation of the stomach was not found to have taken place. The undoubted recovery of more than half the cases treated by gastric lavage is further evidence against a primary duodenal obstruction. Melchior's argument, that a sufficient degree of traction to cause true occlusion by the mesentery would in all probability cause such interference with the mesenteric circulation itself as to lead directly to thrombosis within the vessels, or necrosis of the intestine, is also very suggestive. Finally, the fact that a noticeable degree of mesenteric compression was found in less than 25 per cent of recorded post-mortem examinations, would lead one to infer that mesenteric compression either is unnecessary for the production of acute dilatation of the stomach. or is a secondary and not a primary phenomenon. To this belief most of the more recent observers are inclined—namely, that the stomach dilates first, and that a duodenal obstruction may be produced secondarily in one of two ways: either by compression of the duodenum by the dilating stomach between the tense abdominal wall and the rigid spinal column (Box and Wallace); or that the stomach, as it dilates, compresses the small intestines, crowding them down into the narrow pelvic cavity, where they are held in place by the superimposed weight of the dilated stomach above; the traction thus exercised on the mesentery causes the compression of the duodenum, which in itself leads to a further dilatation of the stomach, and so the vicious circle is set up. This view had the early support of Lecène and Reynier, the latter of whom says: "L'occlusion duodenale postopératoire ne serait, dans ce cas, qu'une complication des plus graves de la dilatation aiguë de l'estomac."

Practically all recent writers, from 1902 onwards, are in agreement in considering that gastric dilatation is the primary phenomenon. How then are we to account for its occurrence? In 1895, Carrion and Hallon demonstrated that section of the vagus nerves in dogs* led to dilatation of the stomach. In 1900, Stieda cut both vagi in dogs on which he had performed gastro-enterostomy two months previously; this led to an acute dilatation of the stomach, despite a patent anastomotic opening. Brinton, in his *Lectures*, looked on the condition as one of a paralysis of the gastric musculature; that the paralysis is a complete one we cannot accept, in view of the many observations of visible, active peristalsis, and in view of the completeness with which the stomach will recover its tone with early use of the tube. Legueu and Reynier have met with the complication after operations on the kidney; they ascribe its development to a reflex innervation disturbance acting through the solar plexus, and compare it with the appearance of acute retention of urine in the bladder following dilatation of the anus for rectal operations owing to reflex disturbance of the hypogastric plexus. It is improbable that a healthy stomach of normal muscular tone can become the seat of an acute dilatation. A certain quantity of gas is ordinarily present in the stomach; any excess of this is readily got rid of by relaxation of the cardiac orifice and contraction of the stomach. If the relaxation of the

* HARTWELL, in 1912, unwittingly repeated their experimental observation on the living subject, when an injury to the vagus nerve, inflicted whilst attempts were being made to check a serious hæmorrhage during thyroidectomy, resulted in an acute dilatation of the stomach with a fatal termination.

cardiac orifice be inhibited, or if contraction of the stomach wall be prevented, we have conditions present which would undoubtedly tend to facilitate dilatation. Kelling's experiments on anæsthetized dogs would certainly seem to show that deep narcosis does prevent relaxation of the cardiac orifice; the same experiments carried out on non-anæsthetized animals failed to produce dilatation. Payer, in a specially investigated series of 300 cases, found that nearly all his patients, after deep chloroform or ether anæsthesia, demonstrated a certain degree of gastric atony, and this partial atony persisted as a rule for twelve to twenty-four hours after operation. As a large majority of cases of post-operative dilatation of the stomach occurred after prolonged or difficult narcosis, these two independent observations are highly suggestive of a valuable etiological factor, i.e., motor insufficiency.

Motor insufficiency, or lack of tone, however, will not produce acute dilatation; it is merely a necessary predisposing factor. For the passive condition of atony to pass into the active state of dilatation the stomach must be overloaded with either solid or liquid food, or distended with gas. French writers (Mathieu, Lardennois, and others) lay special stress upon air-swallowing as the immediate etiological factor in post-operative cases. 'Tiquage,' or aerophagia, is frequently noticeable in nervous people, or in those undergoing some phase of mental excitement or anxiety. (My second patient was an habitual aerophagic, and even when warned of the possible risk in view of the gravity of her condition, she still found the greatest difficulty in checking the habit.) Under ether narcosis we frequently observe violent convulsive swallowing efforts on the part of the patient who is resisting the anæsthetic, during which mouthfuls of saliva mixed with air must be carried down into the stomach, and quite possibly act as the starting-point of an acute dilatation on the operating table. The rapidity with which dilatation sets in in some of the reported cases certainly points to gas being the primary distending agent. Diffusion of ether from the circulating blood, an explanation which has been suggested by some observers, is a much less likely explanation of the source of the gas than that of simple air-swallowing.

In other cases, food and drink may easily play a part in the production of the condition, as is clearly to be seen when a person in ordinary health simply eats himself into the condition. The same factor can play an important part in a patient whose gastro-intestinal musculature is in an atonic state either from recent narcosis or prolonged convalescence; the rapid ingestion of injudicious quantities of food or drink under such circumstances may easily prove the starting-point of an acute dilatation which will gravely imperil the patient's life.

SYMPTOMS.

The most prominent symptoms are vomiting, distention of the abdomen, and collapse. Others are pain in the epigastrium, tenderness over the distended stomach, respiratory embarrassment, visible peristalsis, thirst, and scanty urine. The behaviour of the bowel varies—constipation being the rule, but diarrhœa is mentioned in some of the reports. As a rule, the initial symptom is epigastric pain, due, doubtless, to the rapid gastric distention. If the abdomen be inspected at this stage, the distention in the epigastrium is next noted.

Vomiting sets in early in over 90 per cent of cases, but gives no relief to the pain; once commenced, it becomes the characteristic feature of the condition, and its frequent occurrence at short intervals has prompted Legueu to the not inapt comparison with the continual emptying of the bladder in ischuria paradoxa. The act of vomiting is effortless; the fluid seems to well up, frequently accompanied by volumes of gas. The contents of the stomach are watery; at first yellow or green, due to admixture with bile, they become dark brown or black later, owing to admixture with blood. The vomitus may be of sour offensive odour, but is never 'fæculent.' It may be highly irritant. Carmichael records the production of an eczematous condition of the lips and cheeks from this cause in one of his patients; Reynier has demonstrated the presence of an actual hyperchlorhydria in several of his cases. Free hydrochloric acid is present; lactic acid has been demonstrated in varying quantities. The *bulk* of the vomited material is

astonishing, being far in excess of the amount of fluids ingested. This characteristic of hypersecretion led Morris to give the condition the title 'gastrosuccorrhœa.' Vomiting may cease some hours before death. In one of Legueu's fatal cases, vomiting never occurred at all. Death took place in several cases before vomiting had set in.

Distention develops rapidly; at first manifest in the epigastric and subcostal areas, it steadily extends downwards past the umbilicus, and may even reach to Poupart's ligament within twenty-four to forty-eight hours. The distended viscus occupies the left side of the abdomen, the right side being very little affected. In my own case this was typically displayed, the fundus portion of the stomach running Poupart-wards like a thick curved tube, then the pyloric portion elbowed sharply upwards again in the middle line to a point slightly above and to the right of the navel. Tenderness is often well marked over this distended area. The area of stomach resonance may extend well up into the thorax, even to the nipple line. Durand records a case where the thoracic tympanitic note led to a diagnosis of pseudo-pneumothorax. Loud splashing sounds are easily elicited within the dilated viscus; Leonhardt has described a case where such sounds were produced by the cardiac impulse, and occurred synchronously with the cardiac movements. Any doubt as to the seat of the distention will be readily set at rest by the passage of the stomach tube, as fluid, accompanied by gas, will be expelled, sometimes almost explosively, whereupon the abdominal distention will recede, often, however, only to recur a few hours later.

Pain, at first epigastric, and frequently umbilical in site, is usually present, but varies in the degree of its severity. It is exacerbated by the occurrence of visible peristalsis, the patient sometimes screaming aloud with the intensity of the cramping, vice-like pain. It is rarely altogether absent.

Thirst seems to be one of the most constant symptoms, though my patient, curiously enough, never complained spontaneously. Sometimes it is severe beyond description, agonizing in intensity, and unrelieved by salines, enemata, or drinking. In connection with this craving of the body tissues for fluid to replace that lost by vomiting, we frequently find a marked decrease in the quantity of urine excreted, leading on occasions to even a temporary total suppression.

The behaviour of the intestine is variable, and not easy to explain. Absolute constipation has been frequently noticed, flatus and intestinal movements both ceasing; according to Borchgrevink, their re-establishment is one of the first signs of improvement. A point of special importance has been recorded by four independent observers, viz., that even where a definite degree of mesenteric compression of the duodenum was present, the action of the bowels had not been interfered with ante-mortem (Engström, Walzberg, Zade, Bull, all cited by Borchgrevink.) This directly negatives the suggestion of a paralytic ileus beyond the site of duodenal constriction.

There is no particular rise of temperature or pulse in the early stages; later, the pulse always increases in rate, without any rise of temperature; the respiration rate increases in proportion as the pressure beneath the diaphragm embarrasses the heart and lungs.

Hiccough is not a common symptom; it has been observed by Chavannaz, Campbell Thomson, and Reynier. Cyanosis was noted in three cases (Mayo Robson, Templeton, and Leonhardt). Bloodgood mentions syncope, and vertigo has been observed by Bull and Heine. Dilatation of the pupils is mentioned by Richardson and Farquhar. In Box and Battle's case the raised intra-abdominal tension led to a marked dilatation of the superficial abdominal veins and to œdema of both legs; notwithstanding the severity of these symptoms, the adoption of postural treatment led to this patient's eventual recovery.

POST-MORTEM APPEARANCES.

The stomach is usually found to be enormously distended; in one case-report the diaphragm had been elevated by the dilated cardia to the level of the third ribs; the greater curvature not infrequently is at the level of the symphysis pubis. The distention is largely gaseous, but much free fluid may also be found. The gastric wall is thinned

and stretched out, and the mucosa is often the seat of extravasations, superficial erosions, or fissures, thus affording an explanation of the occasional hæmorrhagic character of the vomitus.

Accounts of the duodenum vary in the different autopsy reports. In a large proportion of the protocols, no mention is made of the duodenum in particular, and we may conclude that in these cases no abnormality was observed. In a smaller proportion, distention is mentioned as being confined to the stomach only, the duodenum being uninvolved in the process. Distention, however, had broken down the pyloric barrier and involved the duodenum in many of the cases. The exact extent of the duodenal distention is of importance in seeking for an explanation of the etiology of this condition. The majority of the earlier authorities found that the duodenum was distended up to the point of its crossing by the fold of mesentery carrying the superior mesenteric blood-vessels; this finding gave origin to the term 'gastromesenteric ileus,' and to the conception that the origin of the condition lay in a mechanical obstruction to the onward passage of the duodenal contents by arterio-mesenteric constriction. In three cases, distention is stated positively as passing *beyond* the point of crossing: in Jessopp's case dilatation of both stomach and duodenum was found, "which passed abruptly to a condition of extreme contraction six inches below the duodenum"; in Hood's case the distention involved the "stomach, duodenum, and first few inches of ileum"; and in 1902 Thomson reported one case in which the distention extended for a distance of eight feet along the small intestine. A true arterio-mesenteric compression was noticed in only about 22 per cent of the post-mortem records; and in only one case (Baümler) did the degree of compression lead to necrosis of the mucosa in the constricted gut.

The small intestine, when mentioned, is usually described as being collapsed, and lying or hanging down into the pelvis, thus leading the observers to the conclusion that the consequent pull or drag upon the mesentery was the directly responsible agent for the compression of the duodenum between the mesenteric vessels and the spinal column; the dilatation of the stomach they thus consider to be secondary to the duodenal occlusion.

Evidence of acute inflammation of the upper portion of the peritoneal cavity is not forthcoming from any of the post-mortem reports I have studied.

PROGNOSIS AND TREATMENT.

An acutely dilated stomach manifests little or no tendency to spontaneous cure; practically all the unrecognized or untreated cases had a fatal issue. Conner's statistics in 1907 showed a mortality of 72 per cent. Laffer's investigations in the following year demonstrated a resultant 63 per cent mortality. Of Borchgrevink's (1913) collected cases, 54 per cent died. Thus, within the past ten years there is an improving prognosis, largely depending upon more widespread recognition of the condition and better methods of treatment. We get a truer perception of the patient's chances if we analyze the mortality of the various methods of treatment adopted:—

1.—Of	31	cases treated	medically,	29	died, a mortality of	93	per cent
2.— „	29	„ „	by operation,	21	„ „	72	„
3.— „	54	„ „	„ lavage,	25	„ „	nearly 50	„
4.— „	30	„ „	„ posture,	2	„ „ „ „	7	„

Thus, of 114 cases where postural treatment was not carried out, 75 died, giving a combined mortality of 65 per cent; *whereas in the* 30 *cases where postural treatment was adopted, the mortality is reduced with a jump to below* 7 *per cent.*

1. **Medical Treatment.**—Of the first of the above groups, those 'medically' treated, only two survived; in one case recovery was attributed to the administration of hormonal; in the other, recovery took place despite the Fabian inactivity of the medical attendant!

2. **Surgical Treatment.**—Of the cases subjected to operative treatment, five varying surgical procedures were carried out, with the following results :—

i. *Gastrotomy*, with evacuation of the contents of the dilated viscus, was carried out on 6 patients, with 5 deaths.

ii. *Gastrostomy* was employed in 7 cases, with 6 deaths.

iii. *Gastro-enterostomy* was carried out 7 times, with 4 deaths.

iv. *Jejunostomy* was fatal in the only case tried.

v. *Exploratory laparotomy* was performed on 8 occasions, and the dilated stomach, on recognition, emptied either by tube or by manual compression. This procedure was followed by 5 deaths.

Thus, we see that of 31 cases operated upon, only 8 recovered. These are highly discouraging figures.

I. Gastrotomy.

Abbott	1904	*Cit.* Laffer	Death
Appel	1899	*Cit.* Conner	Death
Box and Wallace	1901	*Lancet*, ii, 1259	Death
Farquhar	1911	*Brit. Med. Jour.* i, 675	Recovery
Maylard	1909	*Brit. Med. Jour.* i, 653	Death
Hanssen Löberg	1910	*Cit.* Borchgrevink	Death

II. Gastrostomy.

Hoffmann	1904	*Münch. med. Woch.* 2003	Death
Kehr		*Arch. f. klin. Chir.* lviii, 632	Death
Sommarin	1909	*Cit.* Borchgrevink	Recovery
Watson		*Cit.* Laffer	Death
Wright	1897	*Practitioner*, June, 598	Death
Schilling	1907	*Cit.* Borchgrevink	Death
Brown	1899	*Lancet*, ii, 1017	Death

III. Gastro-enterostomy.

Baillet	1909	*Bull. et Mém. Soc. de Chir.* 191	Death
Robinson	1900	*Cit.* Laffer	Recovery
Brown	1910	*Brit. Med. Jour.* i, 727	Recovery
Körte	1904	*Deut. med. Woch.* 1553	Death
Remond		*Cit.* Laffer	Death
Tschudy	1905	*Cor. Bl. f. schwz. Aerzte*, 80	Death
Torrance	1909	*New York Med. Jour.* lxxxix, 70	Recovery

IV. Jejunostomy.

Bloodgood	1907	*Ann. Surg.* ii, 736	Death

V. Exploratory Laparotomies.

Hochenegg	1891	*Wien. med. Woch.* No. 8	Death
Jessopp	1888	*Lancet*, i, 726	Death
Moorhead	1909	*Jour. Amer. Med. Assoc.* i, 1996	Recovery, by tube
Petit	1900	*Cit.* Conner	Recovery
Templeton	1909	*Clin. Jour.* xxxiv, 302	Recovery
Wahlstrom	1908	*Cit.* Borchgrevink	Death
Bollag	1913	*Cor. Bl. f. schwz. Aerzte*, xliii, 262	Death
Moschcowitz	1912	*Ann. Surg.* lv, 614	Death *

* In spite of subsequent postural treatment and lavage.

3. **Lavage Treatment.**—The next mode of treatment, by the frequent or continuous use of the stomach tube, saved one case out of every two. In the 6 cases, where the condition arose during the course of laparotomy, and where the tube was passed without delay, commencing dilatation was immediately checked, and the threatening complication warded off. The earliest possible use of the tube, therefore, is to be recommended warmly. But once the dilatation has progressed to the extent of producing a secondary mechanical obstruction of the duodenum, the tube fails as an unsupported line of treatment. Over and again the remark occurs in the case histories, "Frequent lavage failed to give relief after twenty-four to thirty-six hours, till the prone position was adopted." It seems a fair deduction that the 25 deaths under the above heading were due to the development of secondary duodenal obstruction, and that many of these, even at the eleventh hour, might have been saved by the use of the abdominal position.

4. **Postural Treatment.**—The adoption of the prone position was first recommended by Schnitzler, of Vienna, in 1895, in a patient who developed acute dilatation of the stomach within a few hours of operation for the cure of hernia. His patient had been vomiting incessantly for two days, and on the third day the prone position was adopted, with almost instantaneous relief.

The method is simplicity itself: the patient is turned over on the abdomen, with a large pillow beneath the pelvis, and the foot of the bed elevated; thereby the fluid which has collected in the lowest portion of the stomach is displaced upwards by gravity; the fluid is then more easily evacuated out of the stomach, and relief is given from the downward drag of the loaded stomach on the intestine: the essential feature of this position is the relief it affords from the mechanical obstruction of the duodenum.

The researches of McLean, Hartwell and Hoguet, and Wilkie, on experimental ileus, have shown the importance of the earliest possible replacement by saline solution of tissue fluid lost by vomiting; thereby the blood-pressure is restored, and the failing circulation re-established by the refilling of the vascular system.

In the early use of the tube, the prone position, and free injections of saline solution, we have a triple line of treatment, which, coupled with early recognition of the condition, should almost rob this hitherto highly fatal malady of its terrors.

* * * * * *

Since the foregoing paper was in type, Mr. W. I. de C. Wheeler has given me the following account of a case of acute dilatation of the stomach which was under his care in February, 1918.

The patient was a young man, admitted to hospital complaining of vague abdominal pains. There had been rapid loss of weight, and vomiting was a prominent symptom. Nevertheless a diagnosis of duodenal ulcer was ultimately made, and the abdomen opened on March 4. A well-marked chronic duodenal ulcer was found. During the exploration of the duodenum the stomach commenced to dilate rapidly and progressively until, in a few minutes, it had the appearance of an over-inflated child's balloon. An attempt was made to anastomose the jejunum to the posterior wall, but it was found utterly impossible to apply a clamp to the stomach. The anterior wall of the stomach was then punctured with a scalpel, and collapsed under slight pressure. The puncture wound was closed, and gastro-enterostomy performed. The stomach was little more than normal in size at the commencement of the operation; dilatation commenced at the moment of palpation of the duodenal ulcer. The mesentery was not subjected to any pull, the veins were not dilated, and no cause can be assigned for the sudden distention of the stomach. The patient made an uneventful recovery.

CONCLUSIONS.

Acute dilatation of the stomach is a clinical entity of more frequent occurrence than the text-books would lead us to believe. It may arise after any abdominal operation, or in the course of a long illness.

Gastric distention is the primary condition; in about 25 per cent of cases duodenal obstruction supervenes as a secondary phenomenon.

Gastric atony is necessary for its occurrence; the primary distending agent is most probably gas, due to air-swallowing during narcosis.

Early recognition of the condition and prompt use of the stomach tube will suffice to prevent the secondary duodenal obstruction. Operative intervention for the relief of the fully developed condition is unnecessary, and futile in the majority of cases.

The use of the prone position, and a replacement of tissue fluid depleted by vomiting by intravenous saline solutions, has saved many apparently desperate cases, and should be adopted as a routine procedure.

The etiology of the condition is as yet obscure: further study along the lines of experimental physiology is necessary for its elucidation.

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NOTES ON A CASE OF INTESTINAL OBSTRUCTION: WITH COMMENTS ON BURSTS OF THE INTESTINE.

By RUTHERFORD MORISON, Newcastle-on-Tyne.

The patient, a man, age 66, was admitted to a private hospital, Feb. 21, 1918. I had seen him at home two days earlier and elicited the following history. Ever since the age of twenty he had been troubled at frequent intervals with his 'stomach,' and always had to live with special care. During the 'attacks' he vomited and had some epigastric pain, but never either vomited or passed blood. The 'attacks' were always cured by holidays and freedom from worry, and for the thirteen years preceding the present illness he had been, for him, more than usually well.

The present trouble began in the early months of 1917, and seemed at first to be exactly of the same nature as his previous attacks—epigastric pain and sickness. He was much worried at this time both professionally and at home, and was sleepless.

The digestion trouble seemed gradually to get worse, and about six weeks before my visit an additional pain was added to the digestion one. After dinner at 7.30 p.m. he felt uneasy, and on five occasions had been attacked by paroxysmal pain. After going to bed a feeling of distention, followed by a violent pain, developed. The pain always began at the umbilicus, and sometimes spread to the right side, but never reached as high as the costal margin. The pain was accompanied by loud rumblings of wind and inability to pass flatus. When this could be accomplished, relief came. Otherwise each attack lasted for about two hours, and ended in vomiting the food which he had taken; this and a hypodermic injection of morphia gave relief. The next day after an attack his health was as usual. The last of these attacks occurred a fortnight ago.

Present Condition.—A very thin frail man, who had lost one stone in weight during the past year. On examining his abdomen, I discovered an indefinite but very tender nodule deep in his right iliac fossa, above and internal to the position of the appendix (*Fig.* 126, *a*). Once, momentarily, I felt a spasm of increased peristalsis and heard a rumble. Nothing else was found. The view I took was that he probably had a malignant stricture of the intestine, with threatened obstruction, and he was admitted to a private hospital for further observation, consultation, and examination. *X*-ray examination and a bismuth enema excluded a malignant stricture of the colon. A bismuth meal, followed by *x*-ray examination, showed apparently normal passage of stomach contents through the small intestine into the cæcum. For a few days after this he was encouraged to eat ordinary food, and was examined at frequent intervals. He experienced no discomfort from food, and nothing further being found to confirm my diagnosis, he was sent home with directions to return at once if there was any recurrence of the attacks. Unfortunately he was prejudiced against operation, and though warned by increasing attacks, did not return till March 15, 1918, with active obstruction of small-intestine type, producing severe paroxysmal pains, visible, audible, and palpable peristalsis, inability to pass flatus, and frequent vomiting.

First Operation, March 16, 1918.—His abdomen was opened in the middle line by excision of the umbilicus. Much distended reddened small intestine attempted to escape, but was restrained by a large mop wrung out of hot normal saline. The cæcum was first sought for and found—it was normal. The ileum entering it was of small size and pallid colour. On following this upward, about two feet above the ileocolic junction, a hard nodule, obviously malignant growth, was found, puckering and contracting the gut by extending round it and infiltrating the mesentery. (This nodule was what I had felt

during an early examination.) There was no sign of obstruction above the growth. On following the pallid empty intestine upward about two feet higher a similar growth was encountered, and this was clearly the cause of the obstruction. Above it the intestine was tense, much distended, and reddened, in marked contrast with the flaccid empty pallid condition of the gut below. Remembering a previous experience which had let me and the patient in for a second attack of obstruction soon after the operation, I pulled down and examined the distended intestine above before doing anything further, and about two feet higher than the stricture which was causing the obstruction I found a third, almost occluding the portion of bowel it involved. The mesentery throughout was studded with enlarged glands; there were no growths in the liver or elsewhere in the abdomen.

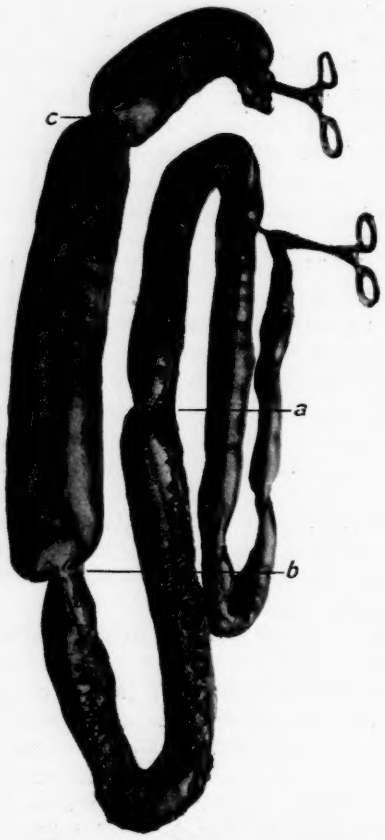

FIG. 126.—Portion of bowel removed, measuring 5 feet 9 inches. It was filled with water from both ends, before being photographed. *a*, Lower stricture; *b*, Stricture causing obstruction found at operation (and now completely impermeable); *c*, Stricture nearest to site of anastomosis. Note specially the distention between *b* and *c*, where the intestine was almost excluded by the two growths and would soon have burst. Microscopically, the growth was a columnar-celled carcinoma.

A large lateral anastomosis was made between the ileum above the highest stricture and the transverse colon.

After this operation the intestinal symptoms at once disappeared, and during the first twenty-four hours flatus and fæces passed; but the patient was so ill and feeble that, having relieved him, I had almost decided to do nothing further. In the third week his general condition had much improved, but recurring griping pains and renewed audible rumblings made it clear that his intestine had increased difficulty in emptying itself, and knowing what we did, we concluded that the bowel was likely soon to burst below the anastomosis and between the two strictures if nothing further was done.

Second Operation, April 2, 1918.—The abdomen was reopened through the old incision. The ileum was divided below the anastomosis, isolated from its mesentery down to the cæcum, and the whole excised, both upper and lower ends being closed by sutures (*Fig.* 126). Recovery from this second operation was in reality uneventful, and the day following it the patient was entirely relieved. In three weeks he returned home well, and continues to be so still, though he has two or three daily motions.

In a paper on intestinal obstruction published in the *Edinburgh Medical Journal* so long as fourteen years ago (July and August, 1904), I wrote as follows:—

> More than once I have seen the ileum united to the sigmoid flexure in obstruction situated between the cæcum and sigmoid. The result has been distention, gangrene, and perforation of the cæcum, and death from peritonitis a few weeks after the operation. Though I have drawn attention to this self-evident fact before—self-evident if the usual competency of the ileocæcal valve to resist the escape of any of the cæcal contents backwards be remembered—it does not seem, judging by recorded cases, to have met with universal recognition.

In the BRITISH JOURNAL OF SURGERY, 1915, No. 10, in a paper with the title of "Notes on Surgical Diseases of the Colon—a Warning," I related cases illustrating and emphasizing the danger of rupture of the intestine following thoughtless operations for the cure of obstruction due to strictures of the colon.

Hamilton Drummond has done much valuable experimental surgical work during the war, and in connection with the subject of my communication has settled the relative importance of bacteria and tension. He isolated a loop of intestine (cats and hares) by dividing it at either end, and restored the intestinal circulation by an anastomosis. In one series of animals he returned the open loop into the abdomen, into which, of course, its contents and secretion discharged. These animals recovered. In another series he sutured the divided ends of the intestinal loop and returned it to the abdomen securely closed. After making a good recovery from the operation, these animals sooner or later all died or were about to die unless saved by a further operation involving excision of the distended loop. Post-mortem examinations showed that the loop was gangrenous and perforated. In all cases it contained putrid stinking contents, and before it burst presented the same appearance as the rotten-sausage appendix.

G. Grey Turner is, so far as I know, the only other surgeon who has published anything dealing with this problem. In the BRITISH JOURNAL OF SURGERY, 1916, No. 14, in a paper entitled, "The Dangers of Intestinal Occlusion," he relates and illustrates cases bearing upon this subject, and says :—

> As exclusion operations are frequently performed, the matter under consideration may be the cause of unsuccessful results more frequently than is generally supposed. Examinations after death are not often made in the case of patients who die at their own homes, especially when the disclosures of a recent operation apparently render them unnecessary. In text-books the subject is either insufficiently referred to or altogether ignored. These considerations have therefore encouraged me to report my experiences.

Compare these statements with the teaching of one of the greatest surgeons in the most recent text-book (Binnie's *Regional Surgery*, p. 216). This encourages me to reiterate a warning already so often given. The large intestine is in question :—

> *Palliative Operations.*—In a certain number of cases the affected bowel cannot be resected because of the involvement of structures which cannot be removed. In these cases palliative measures become imperative. Ileocolostomy, in which the ileum is joined to some part of the colon beyond the point of obstruction, is frequently indicated.

This is surely sufficient reason for drawing attention again to the dangers of such methods as applied to the colon. The case recorded is an interesting proof that the same principles hold good for the small intestine, and that similar warning may be needful for it ; but there are some other points of great practical importance which consideration of the case suggests.

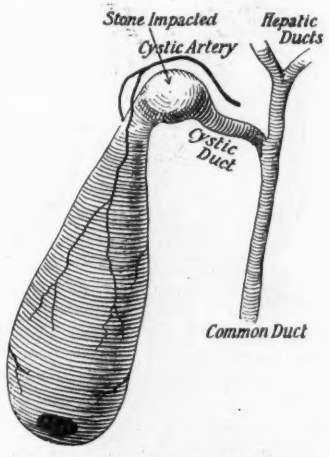

FIG. 127.—Diagram of gall-bladder to illustrate tension gangrene.

Gangrene of the Hollow Viscera.—Before going further I would like to reiterate my teaching as to how the bursting of the excluded bowel is brought about. It is by the formation, first, of round or oval gangrenous patches, and if these do not perforate, of gangrene of the whole of the involved loop. In current literature gangrene of the hollow viscera is usually attributed to bacterial infection, but I cannot recall a single instance in which this view could reasonably be accepted. All of us thought before the war that gas gangrene at least was primarily due to infection with a special organism. It now seems that even in this variety, vascular defects are the essential primary cause, and bacterial infection secondary. The same is certainly true of the hollow viscera, with very rare exceptions.

A much more common cause than is usually believed, and which I have described as 'tension gangrene,' is not yet sufficiently appreciated. By the kindness of the publishers, Messrs. John Wright & Sons, I am able to reprint illustrations of it which appeared

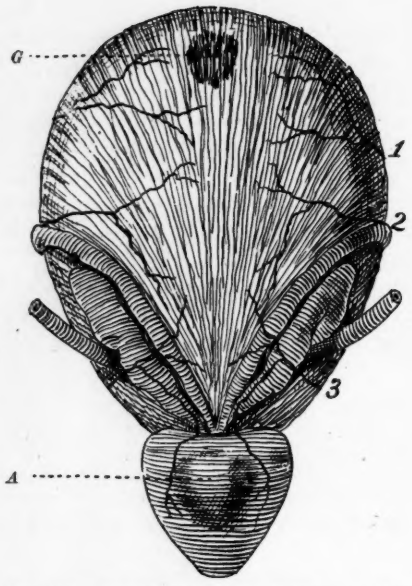

FIG. 128.—Tension gangrene of bladder. *A*, Prostatic abscess; *G*, Gangrene; 1, Superior vesical arteries. 2, Mid-vesical arteries; 3, Inferior vesical arteries. The diagram is from a specimen removed from a young man who had retention of three days' duration from acute gonorrhœal prostatitis and excessive whisky drinking.

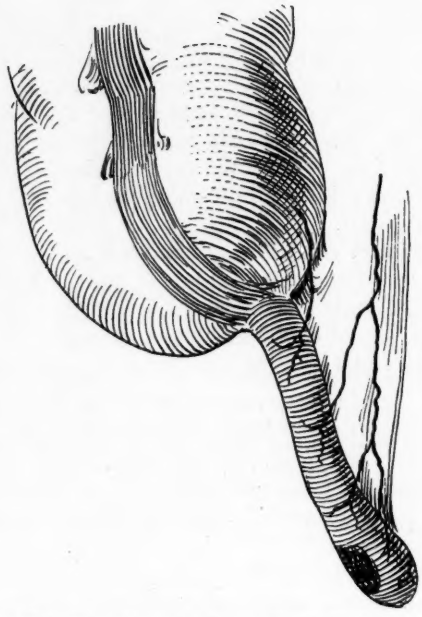

FIG. 129.—Diagram of appendix to illustrate tension gangrene.

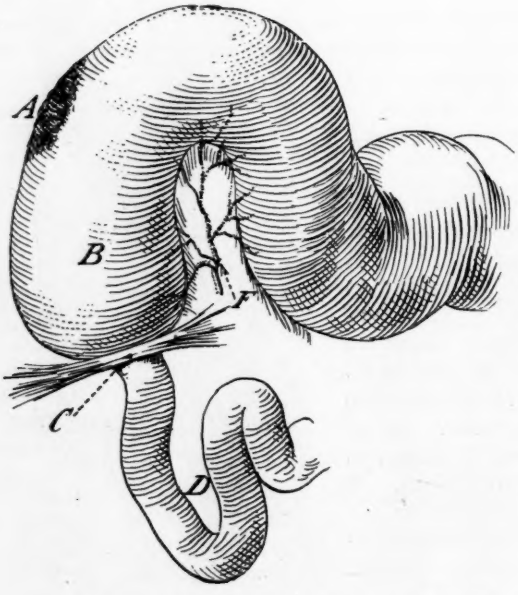

FIG. 130.—Acute intestinal obstruction of two days' duration. *A*, Gangrenous patch; *B*, Small intestine distended: *C*, Constricting band; *D*, Collapsed intestine; *F*, Mesenteric vessels.

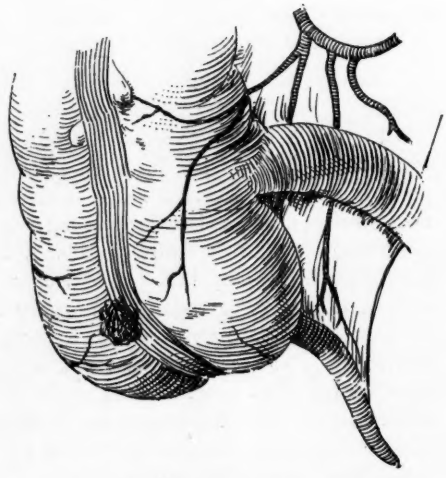

FIG. 131.—Diagram to illustrate tension gangrene in the cæcum.

in my book *An Introduction to Surgery*. They are typical of a form of gangrene frequently seen by anyone on the look out for it, a form which commences as a round or oval patch in a distended hollow viscus at the point furthest from the chief source of its vascular supply (*Figs.* 127, 128, 129, 130, 131).

The case I have related gives an opportunity of describing another cause of gangrene of the hollow viscera which, though not common, may be, and has in my experience proved to be, the cause of disconcerting accidents.

The carcinomatous growth in the case recorded resembles a signet ring, with its seal in the mesenteric border, the ring encircling the gut. In the mesentery there are also enlarged glands. Either the thickened, seal-like induration in the mesentery may obstruct the circulation sufficiently to cause ring gangrene of the gut, or an enlarged gland obstructing one of the larger branches may cause more extensive gangrene of the same. I have had experience of both following simple exploratory operations, and do not doubt that the cardiac failure consequent on operation was the determining cause of thrombosis of vessels interfered with by a growth, either cancerous or sarcomatous.

Another point which consideration of my case suggests refers to the question of palliative operations for cancer, and for tubercle, which so closely resembles it clinically. My own belief, expressed many years ago, is that in the abdomen especially such operations are not sufficiently often performed. In this patient I could entertain no hope of cure; but to give complete relief and restore apparent health, even though for a short time, in an otherwise hopeless and painful condition, is abundant justification of it; and, better still, in a small percentage of cases the results will be more successful than the most sanguine surgeon dare anticipate.

RUPTURE OF THE SMALL INTESTINE INTO THE MESENTERY, THE RESULT OF INDIRECT VIOLENCE OF A MISSILE.

By Major HAMILTON DRUMMOND, R.A.M.C. (T.F.)

Gunshot wounds of the hollow viscera caused by indirect violence have been described by many writers in this war, and Surgeon-General Wallace deals fully with the subject in his Lettsomian Lectures, 1917.[1] In a paper with Capt. J. S. Dunn,[2] we described a condition of laceration of the colon followed by ulceration caused by missiles which passed close to the colon without actually touching the injured gut. We noted how the damage not infrequently extended beyond the bowel wall, resulting in perforation and peritonitis or retroperitoneal cellulitis; such wounds are therefore of so serious a nature as often to prove fatal.

The wounds about to be discussed occur in the small intestine, and were first described by Captain John Fraser.[3] They resemble the colon wounds already mentioned, because the passing projectile brings about an explosive action on the bowel which results in a burst at its weakest point. Before describing the condition further, the following four cases will serve to illustrate the points of importance in this type of wound.

Case 1.—D., age 22, was wounded at 11.30 p.m., and admitted to hospital five hours later. He was much shocked on admission; pulse 120. The abdomen was retracted, rigid, and without any movements. A portion of the transverse colon, with omentum, prolapsed from the exit wound in the mid-axillary line at the level of the tenth rib on the left side; the entry wound was small, and was situated over the fourth lumbar spine.

He was operated upon six hours after being wounded. Operation revealed a bruise wound in the jejunum about three feet from the upper fixed end; a circular hæmorrhage extended round the bowel and up into its mesentery. The leaves of the mesentery were intact, although distended with blood-clot; on squeezing the bowel on each aspect of the bruised area the mesentery was seen to distend with gas, clearly indicating a rupture of the gut between the leaves of the mesentery. The condition was dealt with by freely tearing with dissecting forceps the peritoneum covering the damaged area, and thus exposing the portion of bowel wall uncovered by peritoneum. This allowed of the escape of gas and liquid intestinal contents through a rupture, which showed the typical eversion of mucous membrane usually found. The hole in the gut was closed by a silk purse-string suture, followed by another suture to approximate the torn edges of the mesentery. There were other more severe injuries to the colon and spleen, which accounted for death twenty-six hours after operation.

Post mortem, the bullet track was found to pass forwards and to the left, through the deep muscles of the back, behind the descending colon, and through the posterior margin of the spleen. Then it passed through the diaphragm at its costal attachments, and through the ninth and tenth ribs, portions of which, 1 to 1½ inches in length, were missing.

From a careful study of serial anatomical sections of the body, it would appear that the missile did not come in direct contact with the jejunum, but in its course through the deep muscles of the back injured both colon and jejunum indirectly.

Case 2.—M., age 21, was admitted to hospital six hours after being wounded. As the result of his injuries he died of shock two hours later.

The wound of entry was in the right ilio-costal space in a direct line with the lower angle of the scapula; the exit wound was in the left flank in the anterior axillary line on the same level. The missile had passed below the lower pole of the right kidney, which showed bruising but no laceration; it had entered the body of the third lumbar vertebra, which showed much comminution; and in its course had torn a large hole in the transverse colon near the splenic flexure, and also a loop of the upper jejunum. There were no more ruptures of the small intestine, but the following hæmorrhages occurred in the bowel wall at different points. In the upper jejunum were a number of hæmorrhagic areas. Each bruised

area extended along the bowel for 1 in. to 1½ in. of its length, and involved the whole circumference of the gut. Opposite most of these hæmorrhages the adjacent mesentery showed a triangular-shaped area of extravasated blood, as seen in *Fig.* 133. The intestine between these injuries presented a normal appearance. A second group of similar lesions was present in the lower jejunum, and several single ones occurred in the ileum. None of these injuries, however, showed any rupture of the leaves of the mesentery or of the intestinal wall. The descending colon showed several similar damaged areas.

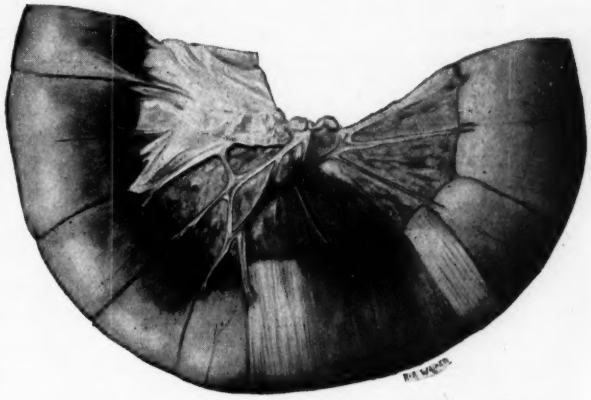

FIG. 132.—Wound of small intestine caused by indirect violence (*Case* 3). Before dissection of mesentery and peritoneal coat of bowel the specimen presented the same appearance as seen in *Fig.* 133. The blood-clot around the ruptured vessel has been removed. Dissection shows thrombosis and rupture of a vessel at a point where it enters the bowel; the muscle coats of the bowel here are lacerated, but show no tear in the mucous membrane.

Case 3.—C., wounded at 2.15 p.m. Aug. 6, 1917, was admitted to hospital 4.50 p.m. on the same day. He died of shock, the result of his wounds, one hour after admission.

In addition to severe limb wounds, he had a compound fracture of the pelvis and abdominal injuries. There was a large entry wound the size of a five-shilling piece above and in front of the great trochanter of the left femur. The missile lay subcutaneously at a point a very short distance behind the anterior superior spine of the left ilium. There was an extensive fracture of the left iliac crest, which could be freely rocked to and fro. The peritoneal cavity contained no blood, and the missile had never perforated it.

The following small-gut injuries were discovered: In the lower jejunum there were two areas of hæmorrhage, each about 1½ inches in length, and extending around the whole circumference of the gut wall under the peritoneum. About one foot of healthy intestine separated the two areas. Both showed extravasation of blood into the mesentery. On dissection, these hæmorrhagic areas showed, after removal of the peritoneum of the bowel and mesentery, a rupture of a large vessel as it entered the bowel wall. The torn vessel was thrombosed, and surrounded by extravasated blood which had found its way along the paths of least resistance towards the larger vessels of the mesentery, and to a lesser extent around the circumference of the bowel wall.

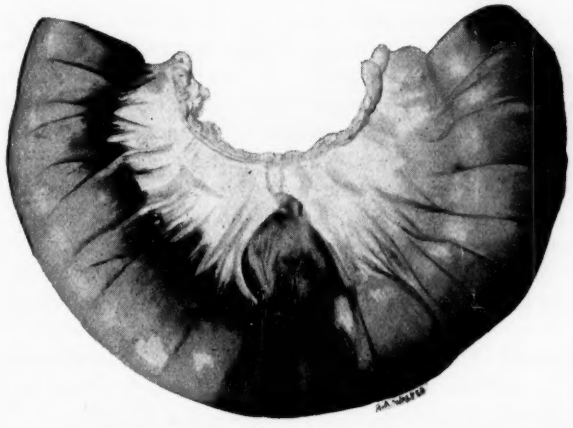

FIG. 133.—Bullet wound of the small intestine (*Case* 4). The leaves of the mesentery are intact. The rupture occurs in the portion of bowel unsupported by peritoneum. At the site of rupture the mesentery is discoloured, from extravasation of blood and intestinal contents between its leaves. Note the hæmorrhagic discoloration around the circumference of the bowel.

The muscle tissue of the bowel wall, at a point where the torn vessels dip through the coats to reach the mucous membrane, showed laceration, but there was no tear of the mucous membrane itself at this point (*Fig.* 132). Examination of the mucous membrane from within showed a thinning of this coat, with hæmorrhagic staining, but no perforation.

Case 4.—F. S., wounded by a shell fragment, was operated upon three hours after his injuries. On admission he suffered from a moderate degree of shock. There was a large single entry wound on the left side of the abdominal wall, midway between the anterior superior spine and the umbilicus, through which about half the small intestine prolapsed. In one place the gut had been completely divided across.

Operation under ether anæsthesia revealed eleven holes in coils of the jejunum and ileum, and in two places the jejunum was found to be divided across, with considerable damage to the mesentery. The damaged area was resected and an anastomosis made. In addition to these injuries, there was a large laceration of the mesentery of the pelvic colon,

and a compound fracture of the ilium on the left side, with much damage to the iliacus muscle.

Examination of the resected portion of small intestine showed four areas with contusion of the mesentery and hæmorrhagic staining around the bowel, similar in appearance to the condition described in *Case* 1. The largest one involved the upper jejunum, with several inches of healthy bowel on each side of it. By making pressure on the gut on each side of the bruised mesentery, gas from the intestine could be squeezed between the mesenteric leaves. The drawing (*Fig.* 133) shows distention of the mesentery between its leaves, due to the extravasation. On examination of the bowel from within, there was a definite circular perforation large enough to admit an ordinary round lead pencil (*Fig.* 134). The vessels in the mesentery leading to the point of rupture in the bowel wall were thrombosed and showed laceration.

There can be no doubt that many perforations of the small bowel due to indirect violence occur in other sites than those just described—namely, into the mesentery—for numerous cases are on record in which, although the peritoneum has not been opened, the gut was ruptured on its lateral or antimesenteric border. Experience has also taught us that when a projectile passes directly through the abdomen, leaving only small entry and exit wounds, sometimes a surprising amount of laceration of small intestine, apparently without any direct wounding of it, may follow. How many of such wounds are caused by direct hits from the projectile and how many by burst-wounds through indirect violence, is an interesting question.

FIG. 134.—Same specimen as *Fig.* 133, laid open to show the rupture into the leaves of the mesentery. Removal of the mesentery showed a typical rosette-like protrusion of mucous membrane, with thrombosis and laceration of the vessels at the point of rupture of the bowel.

Fig. 132 (*Case* 3) serves to illustrate the way in which burst-wounds into the mesentery are caused. The drawing shows an injury to the bowel, caused indirectly by the passing missile, resulting in the rupture of a vessel as it enters the bowel wall from the mesentery. The tear of the vessels in this case must have been due to a sudden impact transmitted from the missile on the wing of the ilium which was fractured; for no missile could have perforated the peritoneum, since it was not wounded. Moreover, this is the point where rupture of the vessels would be most likely to occur from indirect violence, viz., at the junction of a movable with a more fixed portion—a well-known principle applicable to all injuries. In this instance the blow on the intestine was not severe enough to cause a burst-wound of the gut, for it merely shows a wound of lesser degree.

In *Case* 2, where a rifle bullet passed across the posterior aspect of the abdomen, the explanation offered is that some sudden 'pull' action on the small gut tore the vessels but did not rupture the gut, and multiple hæmorrhages on the bowel and its neighbouring mesentery resulted.

In *Cases* 1 and 4, in addition to tearing of the vessels, rupture of the gut occurred. This was probably brought about by the sudden impact of the passing missile on a gas-filled sac. The weakest point in the small intestine lies between the leaves of the mesentery, for there the bowel is unsupported by peritoneum, and gaps in the muscular coat allow the passage through of the vessels from the mesentery to the mucous and submucous coats make it more vulnerable.

It has already been mentioned that similar burst-wounds occur in the colon, and they are produced by missiles as they pass in close proximity to the intestine in the same way.

It is important to note that the results of the small intestine burst-wounds are much less serious than those in the large intestine, for the two following reasons:—

In the first place, in the case of the small gut the rupture takes place into the mesentery; if the leaves of the mesentery remain intact, as in *Cases* 1 and 4, they form a

substantial support, and if circumstances are favourable the wound would in all probability progress to a natural cure. The large intestine, as already stated, bursts more frequently between the longitudinal muscles, and often behind the peritoneum, where no great protection is available.

Secondly, the question of infection: in the small bowel there is less organismal activity in the intestinal contents, and consequently ulceration of the mucous membrane has never been noticed in connection with these wounds except in cases examined twenty-four hours after death. In the case of the large intestine the mucous membrane may slough as early as seven hours after the injury.

It is of interest to note that in this type of burst-wound, whether in the large or small bowel, the burst occurs in the same position as that in which pathological sacculi (or, according to present surgical fashion, acquired diverticula) of that particular part of the intestinal tract are ordinarily found. The common site for pathological sacculi in the colon is in the normal sacculi of the gut; whereas the only place where sacculi are found in the small intestine is between the leaves of the mesentery. In both instances the weak musculature at points where blood-vessels perforate the gut wall is largely responsible for this condition. Moreover, it seems reasonable to think, after observation of the pathology of these gunshot wounds, that small-intestine sacculi might well be produced by trauma received many years previously.

REFERENCES.

[1] WALLACE, Lettsomian Lectures, *Trans. Med. Soc. Lond.*, 1917, xl.
[2] DUNN and DRUMMOND, *Brit. Jour. Surg.*, 1917. v, No. 17.
[3] FRASER and DRUMMOND, *Brit. Med. Jour.*, 1917, March.

SHORT NOTES OF RARE OR OBSCURE CASES.

A CASE OF SUBASTRAGALOID DISLOCATION REDUCED BY OPERATION AFTER SEVEN WEEKS.

By Major S. ALWYN SMITH, D.S.O., R.A.M.C.

Subastragaloid dislocations may be divided into two groups. The true form is that in which the astragalus continues to articulate with the tibia and fibula, but is dislocated from its articulation with the os calcis and scaphoid. In the second variety the astragalus is separated from its articulation with the bones of the leg as well as from that with the os calcis and scaphoid, the so-called complete dislocation.

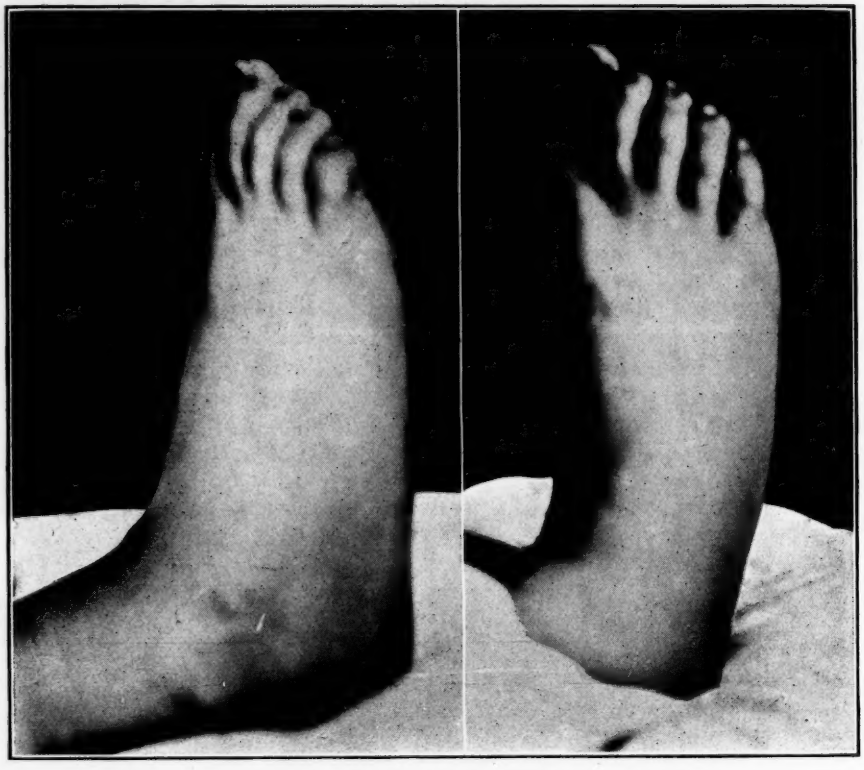

Fig. 135.—Foot before operation.

The case in question appears to come under the former rather than the latter category, although the astragalus was found to be displaced backwards at the ankle-joint, and was completely dislocated from its articulation with the os calcis and scaphoid.

The patient, E. H., a gunner in the R.F.A., was admitted to the orthopædic department of a war hospital on May 22, 1917. He had been injured on April 17; while

he was taking cover in a cellar, a 5·9 shell hit the building and burst through the ground floor, the timbers of which fell on the patient's legs. He was taken to a casualty clearing station, and an unsuccessful attempt was made to reduce the deformity of the right foot under a general anæsthetic. A box splint was applied, and he was sent down the line to England. A second attempt to reduce the deformity was made at a hospital in this country ; but again without success.

Condition on Admission.—There is a Pott's fracture of the left ankle, uniting in good position. The right foot (*Fig.* 135) is markedly adducted at the mid-tarsal joint, and is in a position of extreme varus, the appearance of a well-marked case of club-foot. An adventitious mass of bone is felt in front of the external malleolus. The back of the ankle-joint is markedly thickened, obliterating the contours of the malleolus and the tendo Achillis. Circulation is good ; there is no evidence of gangrene, but the foot is slightly swollen as if there is some slight impediment to venous return. A skiagram (*Fig.* 136) shows the astragalus to be rotated outwards and displaced backwards on the os calcis, and luxated backwards from the lower surface of the tibia. The bone is markedly rotated, and the head of the astragalus is seen to be absolutely dissociated from its normal relationship with the scaphoid.

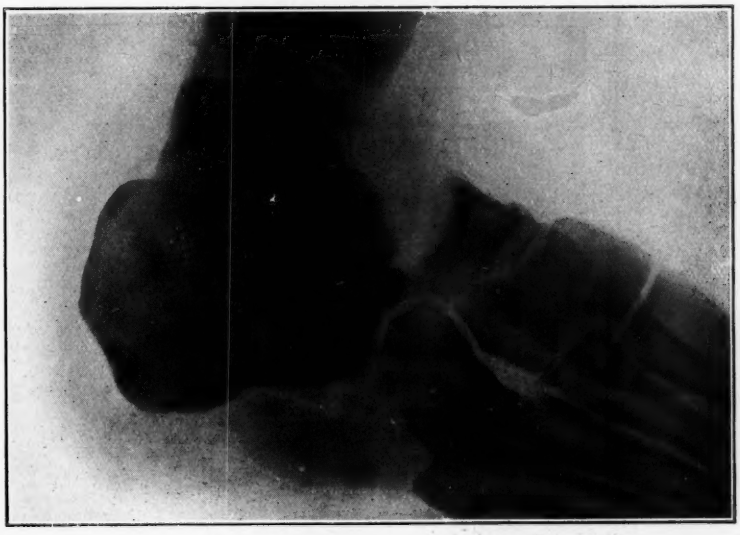

FIG. 136.—Skiagram of foot before operation.

It was resolved to operate with a view to correcting the deformity by astragalectomy or open reduction.

Operation.—This was performed on June 2, forty-six days after the injury. A 5-in. curved antero-external incision was made in front of the external malleolus, opening into the ankle-joint. The front of the ankle-joint was exposed, and the anterior edge of the lower articular surface of the tibia was dissected free from adhesions. A mass of bone covered with adhesions was found projecting between the external malleolus and the cuboid. On dissection this was found to be the head and neck of the astragalus. The astragalus was thus shown to be displaced backwards and rotated externally forty-five degrees. A large Lambotte lever was placed beneath the tibial aspect of the ankle-joint, and the astragalus forced forwards. The interosseous ligament was found to be ruptured or badly stretched, as the astragalus moved perfectly freely on the os calcis. The astragalus appeared to be well nourished, the cartilage being of normal colour, and the neck of the bone bleeding when the adhesions were freed from it. On this account it was resolved to attempt reposition of the bone instead of resorting to astragalectomy.

A gauze mop was interposed between the gloved hand and the head of the astragalus, and the rotation was corrected by strong digital pressure. A smaller Lambotte lever was now placed behind the scaphoid, the anterior part of the foot was forcibly abducted by this leverage and by the manual efforts of my assistants, the head of the astragalus was forced into place, and when the foot was brought to a right angle and everted it was found that the bone remained in its true anatomical position. The wound was closed

with catgut without drainage, and the foot splinted with a Thomas talipes shoe. The healing was uninterrupted.

Post-operative Treatment.—Daily massage began on June 18, without any passive movements; there was no untoward swelling. Towards the end of July the patient started to move his ankle voluntarily, so passive movements and faradic stimulation were ordered. Voluntary movements were much improved in the beginning of August. On Sept. 1 patient began to walk with light boots, the right one being fitted with an inside iron and outside crook heel and external sole flapper. He walked with crutches for two months, and substituted sticks in November. All movements of the foot and ankle were now free and painless, and the patient could walk for three miles without limp or disability. There was no disturbance of circulation whatsoever. (*Figs.* 137, 138.)

FIG. 137.—Foot after operation.

FIG. 138.—Skiagram of foot after operation.

This case is of interest on account of the nutrition of the astragalus. The major part of its blood-supply comes through the sinus tarsi in connection with the interosseous ligament, and one cannot help feeling that these vessels must have been damaged, on account of the ease with which the bone moved on the os calcis.

My thanks are due to Dr. Bayumi, one of my assistants, who has been in charge of the case, and who has supplied me with the notes.

A CASE OF CONGENITAL ELEVATON OF THE SCAPULA (SPRENGEL'S SHOULDER).

BY CAPTAIN RALPH M. DE MOWBRAY, R.A.M.C. (T.)

IN view of the comparative rarity of the above deformity, the following case may be thought worthy of record.

Pte. M., age 21, was admitted to hospital on Feb. 28, 1917, with a gunshot wound of the right shoulder. During the course of examination it was found that the left shoulder was markedly raised as compared with the other side, and that the movements of the scapula on the chest-wall were limited in all directions. The left arm, moreover, could not be raised vertically above the head.

Palpation at once revealed the presence of a bony process running from the vertebral

FIG. 139.—Skiagram showing abnormal bone articulating with the scapula and vertebral column.

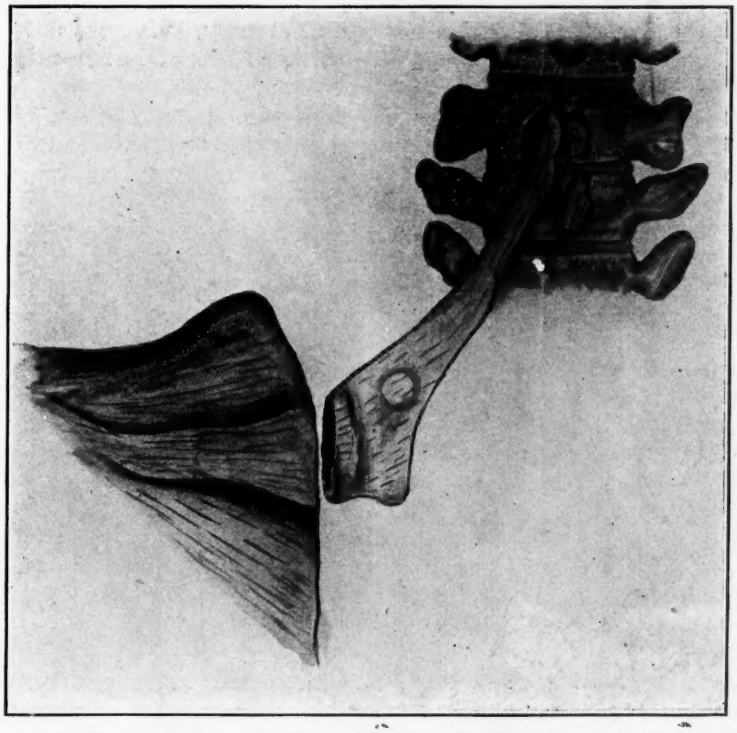

FIG. 140.—Semi-diagrammatic representation of the abnormal bone and its articulations.

border of the scapula, at the level of the spine, upwards and inwards towards the spinous process of the seventh cervical vertebra. *X*-ray examination, kindly undertaken by Captain Garfield Evans, showed a well-formed bone, not unlike a clavicle in general appearance, articulating at its outer extremity with the vertebral border of the scapula (*Fig.* 139). The exact method of attachment of the inner end was, however, difficult to determine, owing to the density of the vertebral bodies.

The patient readily consented to have the bone removed, and this was done on April 6. Superficially the bone was found to be covered by the trapezius muscle, while attached to its deep aspect was a thick muscular belly, apparently a detached portion of the levator anguli scapulæ. As already shown by the *x*-ray plate, a well-formed joint, with an inter-articular fibro-cartilage, was present at the outer attachment of the bone, whilst on its inner extremity were two facets, articulating with the lamina and side of the spinous process of the seventh cervical vertebra (*Fig.* 140). On removal, the bone was found to be 4½ in. in length, the outer end being broad and flat, while the inner tapered almost to a point.

Professor Shattock, who has kindly interested himself in the case, states that the only clue to the morphology of this condition lies in a cartilaginous bar which occupies a somewhat similar position in a special group of fishes (Dipnoi), the attachments in their case being to the top of the scapula and the *occipital* region.

It is satisfactory to note that considerable improvement in the movements of the arm at the shoulder-joint and of the scapula on the chest-wall occurred after the removal of the bone.

CONGENITAL ABNORMALITY OF THE WRIST.

By Captain A. WALDO CONNELLY, A.A.M.C., and Major HOLMES A'COURT, A.A.M.C.

Patient, E. B., is a private in the Australian Imperial Forces, age 17 years 10 months. He enlisted in the Australian Imperial Forces in February, 1916. He did ordinary duty for one month. He was then bugler until his arrival in France in November, 1916. He was ' in the line ' on ordinary duty for three months. At this time—that is, in February, 1917—he fell and ' sprained ' his right wrist, and states that a swelling appeared on the dorsum. He was then transferred to Divisional Headquarters on account of being under age, and served as batman, although he had difficulty in lifting baggage, etc. The right wrist became more swollen in January, 1918, and he was invalided to hospital.

Family History.—The parents are healthy, and there is no history of any abnormality. The patient has three sisters, age 21, 15, and 12 years respectively; all are said to be normal. There are also two brothers, age 13 and 6 years; patient states that his elder brother has ' weak wrists,' exactly like his own, but he believes the younger brother to be normal.

On Examination.—The patient is a fairly well-made youth, 5 feet 4 inches high, and weighing 9 stone. He states that he has always noticed a " weakness of his wrists, especially the right." Eight years ago his mother took him and his brother to a doctor, on account of " weakness of their wrists, and a hollow over his brother's left wrist." No radiographic examination was made at that time.

At the present time (February, 1918) there is a fluctuating swelling on the dorsal aspect of either wrist, which appears to communicate with the synovial lining of the joint, and can be made to disappear on pressure (*Fig.* 141). It is apparently a diverticulum or hernial protrusion of the synovial membrane, more marked on the right wrist than on the left. Movements at both joints are unrestricted, except that extension of the right wrist produces pain, and the grip of the right hand is weak.

Radiography (*Fig.* 142).—Stereoscopic skiagrams were examined, and show :—

Right Wrist.—There are only six carpal bones present. The trapezoid, os magnum, unciform, and pisiform appear to be definitely recognizable. An imperfectly developed bony

element in relation to the pisiform apparently represents the cuneiform. The small half-moon-shaped bone on the radial side of the carpus is situated in a plane well in front of the trapezoid; the base of the first metacarpal appears to articulate in front with this bone, and also directly with the radius. If, therefore, this be regarded as representing the trapezium, then the scaphoid and semilunar are entirely absent.

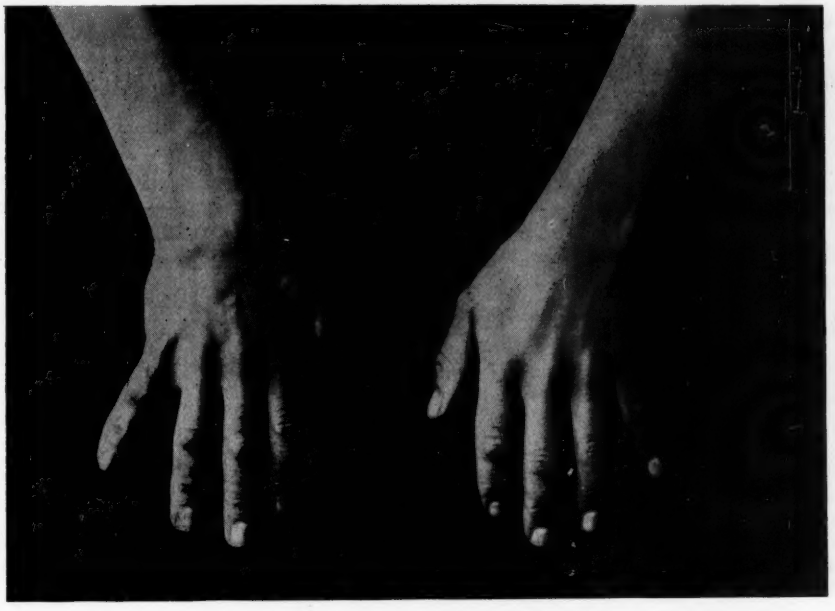

FIG. 141.—Congenital abnormality of the wrist.

Left Wrist.—All the bones are represented, but show many anomalies. There is no styloid process at the radius. Epiphyseal lines have disappeared early.

Ankles.—All the tarsal bones are present in both feet.

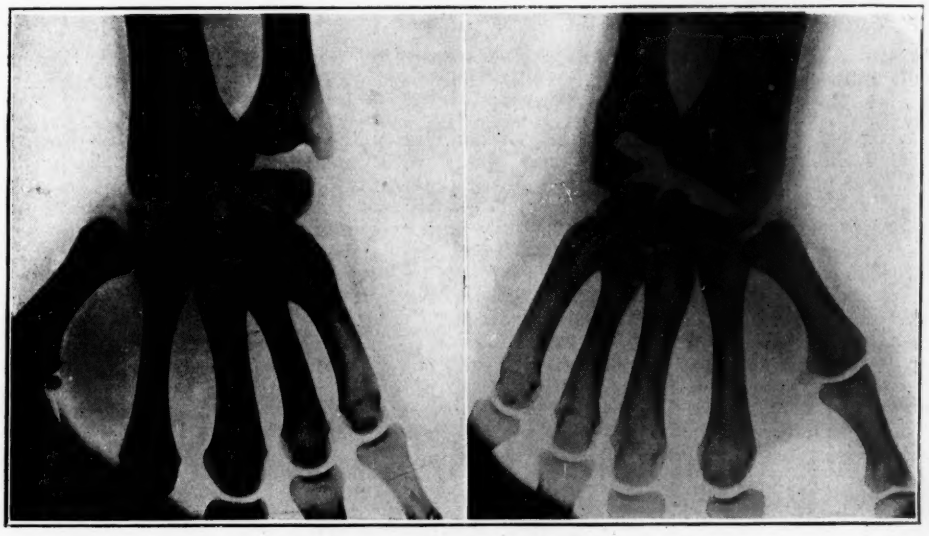

FIG. 142.—Skiagram showing abnormal carpal bones. The right- and left-hand figures show the right and left hands respectively.

REVIEWS AND NOTICES OF BOOKS.

Handbook of Operative Surgery. By W. I. de Courcy Wheeler, M.D., F.R.C.S.I., with an Introduction by Sir Alfred Keogh. 8vo. Pp. 372, with 226 illustrations. Third edition. 1918. London: Baillière, Tindall & Cox. 12s. 6d. net.

A third edition of this book brought out in these days of difficult publishing witnesses in no uncertain way to the value and usefulness of Mr. Wheeler's work, showing its appreciation by the readers for whom it is written. Everyone who has taught operative surgery will welcome a work from the pen of an authority of such ripe surgical experience as that of the author.

The book is comfortable in size, portable, and printed on good paper. Sixty-nine illustrations have been added to it, not all of which, however, are new or even up-to-date. *Figs.* 196, 220, 224, and 225, for example, appear to illustrate inaccuracy in the artist and an oversight on the part of the author and publishers. Then, pubic hair flourishes in many operations in this era of aseptic surgery: that, at least, is an anachronism. No teacher would instruct a student to open the trachea in a tracheotomy as represented in *Fig.* 56. But these blemishes in the illustrations in no way detract from the excellence of Mr. de Courcy Wheeler's advice and instructions. The book is an excellent one for those "rushing from the medical schools into the service of the Army and the Navy."

That a third edition is called for testifies to its value and usefulness, and to the fact that the object for which the book has been written has been attained; but three points are open to criticism: (1) The inclusion of the civil operations for harelip, cleft-palate, carcinoma, and so on; (2) The exclusion of much military surgery, such as blood-vessels and infections; and (3) The illustrations.

Précis de Radio-diagnostic Technique et Clinique. By Dr. Jaugeas, with Preface by Dr. Béclère. Large 8vo. Pp. xxviii + 563, with 63 plates and 220 illustrations. 1918. Paris: Masson et Cie. 24 fr.

A perusal of this interesting volume reveals clearly the high value of radio-diagnosis in practical medicine and surgery. It also shows with equal clearness how rapidly and to what an extent this branch of diagnosis has extended its field since the early days of radiography. Perhaps even of greater value is the proof that the radio-diagnostician must now be recognized as one of the more important of the newer consultants. The day has gone when any one who could take an *x*-ray picture was good enough to interpret what he had produced. Dr. Jaugeas, in his title, has clearly placed the radiologist as both a technical man and a clinician, and in the many pages of his work he again and again shows that clinical and technical skill must go hand-in-hand if satisfactory and useful results are to be obtained. The recognition of the radiologist as distinguished from the radiographer will become an assured one when the profession realizes clearly that in radiology a new and most useful field exists for the investment of the best type of brain. The publication of books on the subject as valuable as the present one will go a long way towards furthering the advancement of radio-diagnosis and the specialists who practise in it.

The book is full of clinical material which must be exceedingly useful to the practising surgeon and physician at the present time. The technical side of the work is very completely dealt with in phraesology which reaches a high standard of excellence. The French language seems to lend itself to clear terse descriptions which are readily understood.

The physics of the *x* ray and kindred phenomenon are interestingly described, and a great many experimental data given. This section of the work should prove useful to the

medical man whose knowledge of physics may be elementary. In order to follow the phenomena produced by *x* rays in medicine, both in diagnosis and in therapeutics, a certain knowledge of physics is essential. Dr. Jaugeas supplies this necessary information in a very concise manner.

Instrumentation is thoroughly dealt with, and also various kinds of installations; it is noticeable that the descriptions are almost entirely confined to French types of apparatus, with the exception of the Coolidge tube, which is generously dealt with. Surely there is something good to be obtained from allied countries! One would have liked to see a description of the Baese localizer, which has been so well described by Dr. Bergonié, and so warmly recommended as a reliable instrument.

The book gives a comprehensive *résumé* of the technique necessary for the examination of the whole body, and it is full of useful practical points of value to the radiologist. The technical details are gone into most thoroughly, each part coming in for careful co-ordination. The various methods for obtaining the radiogram—by instantaneous, rapid, and longer exposures—are fully considered.

A noticeable feature is the absence of any attempt to supply exposure tables for the various parts. This is excusable at present, when there is such a diversity of opinion on the matter; but one would have been pleased to observe an indication of a desire on the part of the author for standardization of exposures. Possibly that may come later.

An attempt is made to standardize the positions for the radiography of the various parts of the body. This is a useful section of the work, and will be valuable to the beginner, who so often fails to grasp the essentials of posture in radiography. In this relationship it is worthy of notice that in another section of the work the importance of accurate centering of the *x*-ray tube is made clear, particularly in relation to the localization of foreign bodies. It is equally important, if accurate work is to be looked for, that the *x*-ray bulb should be correctly centered if standard positions are to be obtained; then distortion can be eliminated, and the relative position of parts on the plate ascertained.

Normal radiography is fully described in an interesting section on the subject; this is undoubtedly one of the best parts of the book.

The localization of foreign bodies forms a useful section; in it are described the methods most commonly employed by our allies. Geometrical considerations are fully gone into, and the extraction of the foreign body by the aid of radioscopy is clearly described. The various aids to the operation are illustrated. The compass of Hertz is described at great length, and other forms of a similar type are illustrated.

There is an interesting chapter on fractures, which is very well illustrated by a number of good plates. This will appeal to surgeons. The fallacies of interpretation are clearly demonstrated by drawings and radiograms. The value of radiography in the diagnosis of fractures and the sequelæ of fractures is particularly well shown. The aid it can render in the observation of the repair of bone by examination at intervals and the study of the formation of the bony cicatrix, is particularly pointed out. Numerous interesting points are entered into which all go to show that at the present time radiography is indispensable, and that the greater the clinical and technical skill of the radiologist, the greater will be the value of a collaboration between him and the practical surgeon; it almost points to the need for a surgeon radiologist.

Diseases of bone, including osteomyelitis and tuberculous and syphilitic lesions, are very well described. Tumours of bone also receive adequate description.

The important subject of tuberculous arthritis and osteo-arthritis is described at length; all the principal lesions are dealt with, and a number of them illustrated. This is, perhaps the best manner in which to deal with the subject; it clearly indicates that before long we shall have monographs of the important diseases of bones and joints and other structures, instead of, as at present, compressing all into one large volume.

Lesions of the skull and face are also dealt with. An interesting description is given of deformities of the sella turcica and lesions of the pituitary body, illustrated chiefly by a number of rough drawings; the radiographic illustrations are not of a sufficiently high standard to adequately demonstrate the lesions referred to. Sinus radiography is briefly dealt with. Dental radiography is illustrated by a good plate with four good radiograms.

A long chapter is devoted to lesions of the internal organs, and many good radiograms are reproduced. It is impossible in a review to deal adequately with the sections devoted to the thorax, the abdomen—particularly the alimentary canal—and the renal organs. Suffice it to say that this section is full of radiographic and clinical data of a very high standard. A careful perusal of these interesting pages will well repay the radiologist, the clinician, and the surgeon. The heart and aorta are well described, and the various lesions fully considered. The last section of the book is devoted to the urinary tract: there is a good description of the technique for the exploration of the ureter and renal pelvis by means of collargol and bismuth, a method of great value in the elucidation of obscure symptoms.

The book, taken as a whole, is a first-class production, and serves to show the high

standard of technique which has been evolved by our French *confrères*. Dr. Jaugeas is to be congratulated on the production of a work which amply testifies to his great industry, technical skill, and clinical acumen. It is specially welcome at the present time to English readers as an indication of the value attached to radio-diagnosis in France, and indicates clearly that nothing but good can accrue from an interchange of ideas, technique, and clinical experience between workers in this and allied countries. The time is ripe for a closer *rapprochement* between the radiologists of English-speaking countries and of France.

The Fitting out and Administration of a Naval Hospital Ship. By EDWARD SUTTON, Fleet Surgeon R.N. Pp. 118, with numerous illustrations. 1918. Bristol: John Wright & Sons Ltd. 8s. net.

ONLY one who has had experience of the work on hospital ships can realize the thousand and one difficulties that fall to the lot of the medical officer in command. This small work of a little over one hundred pages serves a most useful purpose, and no officer about to command a hospital ship can afford to be without it.

The opening chapter on the evolution of the hospital ship is most interesting, dealing with the first crude attempts by the French to employ sailing ships as hospitals. The inevitable handicap of then-existing conditions seriously interfered with the arrangements for the comfort and proper treatment of the patients. Refrigerating chambers were unknown, so that fresh food could not be stored, and even the water was only such as could be stored in casks. The noise and bustle of navigating and working the ship, and the necessarily uneven keel of ships propelled by sails, did away with all comfort, and rendered treatment by the medical officer most difficult and unsatisfactory.

Most, if not all, of the hospital ships at present employed have been converted from passenger and cargo ships. The ideal would be to have ships specially designed for hospital purposes. The Japanese have adopted the middle course of designing certain mercantile craft with a view to conversion, if required, into hospital ships. The desiderata are well set forth in the book under review.

Chapter II deals with the Geneva Convention, and gives the rules governing the employment of the hospital ship, all of which it is necessary that the officer in command should be well versed in.

Chapter III indicates certain points to be taken into account when improvising ships for hospital purposes: (*a*) In the selection of a suitable vessel; (*b*) In the location of specific hospital departments.

In the description of the *S.S. Drina*, all details of construction, cabin and cargo space, engines, wards, lounges, boat capacity, accommodation of crew and officers and patients, are given exactly, and no detail is considered too small to enter into. In this way the inexperienced officer who studies this manual can obtain in a few hours what it has hitherto taken a novice months to learn, and that only by bitter experience—in many cases at the expense of the comfort of officers and patients.

A chapter is given on embarkation and disembarkation routine, on information required for the ambulance train, and on book routine and registers. Illustrations of man-handling patients, and diagrams of registration boards, entry and discharge forms, and various other necessary documents, are given towards the end of the book.

The work reflects great credit on the author, who has produced a most useful manual of permanent value.

Poliomyelitis in all its Aspects. By JOHN RUHRÄH, M.D., and E. E. MAYER, M.D. Large 8vo. Pp. 305, with 118 illustrations and 2 plates. 1917. Philadelphia and New York: Lea & Febiger. $3·50.

POLIOMYELITIS, by Ruhräh and Mayer, of the University of Maryland Medical School, is essentially a medical text-book which has strayed into the precincts of a surgical journal. It is a welcome guest, and if therefore immune from criticism, may nevertheless not escape without some trifling eulogy.

It is a most refreshing and lucid account of a fearful epidemic disease. In a delightful historical sequence it presents the patient work of more than a century which has led to the final recognition of the infective nature of the disease, and which leaves the workers hot

on the scent of the mode of spread and the means of prevention. To the surgeon, upon whom the aftermath of terrible deformities falls most heavily, such advances in knowledge are indeed welcome. What surgery can accomplish for such cases, and how best it may be accomplished, is meticulously set forth in a special segment of the book. This—one of the least interesting segments—contains nothing new, and hardly refers to what is the common knowledge of surgeons of experience—that the sum-total of such accomplishment is small. But the public have no illusions upon that point, and their outlook may well be summarized in the following quotation (pp. 96, 97): "Paralysis is the most dominant symptom in a large proportion of cases, and the persistence of paralysis, with the consequent loss of power and function, is what most fixes the attention of the physician and of the layman. A disease may be feared on account of its causing death, but a disease which permits the patient to live in an enfeebled condition is even more dreaded, and its occurrence in a community makes a much deeper impression. The comparative callousness with which the population watches the annual destruction of infants by the diarrhœal diseases is too well known to be commented upon, while 50 cases of poliomyelitis will throw a community of 500,000 into a panicky state of mind." It is not within the power of practical surgery ever to allay such public apprehension; but hope for the public and surgeon alike is stored in the pages of this book, and there is no member of the medical profession of whatever branch who should not feel himself richly repaid by having read it.

Radiography and Radio-Electro-Therapeutics. By ROBERT KNOX, M.D. Vol. II. Pp. 616, with 15 plates and 100 illustrations in the text. London: A. & C. Black Ltd. 15/- net.

THE popularity of this book since it appeared in 1915, as one of the Edinburgh Medical Series, has induced the author to deal with the subject of radio-therapeutics rather more fully, and to publish the second edition in two volumes. Vol. II is devoted entirely to radiotherapy, and is the book now under review. It is divided into three portions: (*a*) *X*-ray therapeutics; (*b*) Radium therapy; and (*c*) Radium and *x* rays, the latter part dealing with combined treatment by *x* rays, radium, and other radiations.

From the point of view of the student, one would have liked to have seen technical details described rather more fully; but the subject is dealt with in sufficient detail to make the book an extremely valuable one both for the surgeon and the student who is taking up radiotherapy. The experienced specialist will also find in it much matter of interest. A small section by Mr. Percival Cole on the value of radiation in the plastic surgery of the face and jaws will be found of interest to those engaged in this class of work, and there is no doubt that more attention paid to this subject would be of benefit in many military hospitals.

The book is well and clearly written, and the errors are few and are mostly typographical. It may be confidently recommended to all those interested in this important branch of medical science as the most complete and up-to-date treatise published on this subject at the present time. A word of praise is due to the author for producing a work so well thought out in such times as the present.

Studies in the Anatomy and Surgery of the Nose and Ear. By ADAM E. SMITH, M.D. New York. 4to. Pp. 157, with 45 plates and figures. 1918. New York: Paul B. Hoeber. $4.00.

"THIS little volume deals with the anatomy of the nose and ear from a surgical standpoint," as the author states in the preface; but there are also sections dealing with practical points in treatment; thus, while the book is essentially a series of plates illustrating the anatomy of the nasal sinuses and the parts of the temporal bone concerned in mastoid operations from a surgical point of view, the author has touched on the technique of the surgery of the nasal accessory sinuses, and on mastoiditis and its complications.

The opening chapter is devoted to "The importance of nasal breathing." We quote the first six lines: "For several years past much attention has been given to the importance of the removal of superabundant adenoid tissue, which is looked upon as the causative factor for all ills which really are due to defective nasal breathing, without a conception of the truer elation of the various factors involved. I will here dwell particularly on the great importance and marked influence of air pressure upon the internal structures of the nose during normal breathing." The author proceeds to explain that the "air passing through the nasal fossæ from infancy onward exerts marked pressure on all structures within the nose, pushing the lateral walls outward and the floor downward sufficiently to give the space required for the growing capacity of the lungs.

. . . . The air normally conducted through the nose and nasopharynx will produce sufficient pressure to support the vessels in the adenoid tissue normally present in the nasopharynx, and hence keeps its growth within bounds." Such false physiological premises naturally lead the author to attribute the clinical features of typical adenoids to mouth breathing: "The absence of air pressure within the nose has permitted the fossæ to remain narrow. If they are sufficiently roomy the mucous membrane covering the turbinals is swollen from non-support. . . . In those in whom there is an abundance of adenoid tissue lining the nasopharyngeal wall, the vessels of this tissue, being unsupported, are continually in a congested state." Not one word is uttered to suggest that infective catarrh is the cause of the turgescence of the nasal mucosa and of the lymphoid hypertrophy which, by causing nasal blockage, compels the child to breathe through its mouth: the whole clinical syndrome of adenoids is explained by the author's curious theory, which we have indicated in his own words, and which, though we are bound to admit its originality, is completely at variance with physiology, physics, or clinical experience as usually accepted.

Chapter II is entitled, "Some suggestions on the treatment of intranasal conditions," and here we find the author recommends what he terms "nasopharyngeal gargling," especially for prolonged use for the cleansing of the nose. It is performed as follows: "After cleansing the teeth and rinsing the mouth, the throat is gargled to free it from food particles and mucus. . . . After taking a long breath, a mouthful of the cleansing solution chosen is taken, the head is thrown back, . . . the palate is relaxed, and the air is blown through the nose. The fluid thus mounts higher and higher into the nose until it is discharged from the anterior nares." While truly an original method, we cannot help stating that this seems an unnecessarily dangerous and even dirty substitute for the more usual spraying of the nasal passages through the anterior nares.

When we turn to the surgical methods for approaching and exposing the nasal sinuses, we cannot avoid the conclusion that the author is ignorant of the more generally accepted technique amongst specialists in this regional surgery of the nose, and that while for anatomical display the routes suggested leave little to be desired, from the clinical standpoint they are sometimes reprehensible. For instance, in the section on "Exposure of the maxillary antrum," p. 89, he says, "if desirable to carry out the flap method as described on *Plates* XXVI and XXVIII, the tissues are incised to form a flap with its base above and including the entire wall of the antrum." True, the author leaves it to the imagination as to what circumstances call for such a procedure, but we are allowed to infer that this is put forward as a regular and legitimate means of exposure of the maxillary antrum, without a word to justify the advocacy of a method which is entirely out of keeping with modern rhinology.

The descriptions of many operations which are to be found in almost every ordinary modern text-book on diseases of the nose are sound, though often too cursory for guidance; it is when the usual routine methods are replaced by the author's own that we find it so difficult to take him seriously.

Much care has been taken in presenting with great accuracy and delicacy a series of plates which are instructive and of anatomical value, and on this aspect of his painstaking work the author, his collaborating artist, and the publishers deserve our thanks and commendation.

Surgery and Diseases of the Mouth and Jaws. By VILRAY PAPIN BLAIR, A.M., M.D., F.A.C.S. Large 8vo. Pp. xxxi + 733, with 460 illustrations. Third edition. 1918. London: Henry Kimpton. 30s. net.

THE author, in his preface to this edition, indicates that the added matter deals largely with the surgery and treatment of war injuries; the bulk of the book has been increased by 100 pages. Such an endeavour is heartily to be welcomed, though its form may not be entirely convenient. This is a necessary disadvantage of incorporating special matter in a book devoted to general lesions. On the other hand, it may be argued that the treatment of these special injuries is so intimately connected with the general principles of surgical procedure that divorce is impossible, or at any rate undesirable. Skilful correlation of a special section devoted to the problems involved would have been arduous; it certainly would have been more satisfactory. The author has been careful to indicate and emphasize principles of treatment based on the clinical experience of sound observers. The policy is admirable, and the more noticeable because the literature of the subject tends to obscure what is fundamental by diffuse elaboration of unessential details. The interdependence of surgeon and dentist is stressed verbally, and confirmed by the scope and treatment of the subjects dealt with.

The least helpful chapters are those that deal with plastic surgery and the surgical restoration of bony defects. Israel's operation is rightly condemned. The restoration of the lower lip by vertical flaps raised from the neck as shown in *Figs.* 234, 235 is unsound, and differs essentially

from the method of Dowd, with which it is compared. Morestin himself admits that cartilage grafts do not determine firm continuity when used to fill a bony defect. The space devoted to this operation might well be used to describe other and more effective methods. The same remarks apply to the method of transplanting a bony implant. Imbert & Real have adopted this plan in a series of cases, but the results obtained have not been satisfactory.

Chief among the controversial matters considered are the primary suture of wounds; the use of open-bite splints; and immediate as opposed to gradual reduction of bony deformities. These questions are approached in a manner that is at once accurate and broad-minded. Guidance on these and other matters can only be obtained, however, by assembling scattered references, a disadvantage previously mentioned.

In the section on general anæsthesia, it is pleasing to note that the value of intratracheal insufflation is justly recognized.

There are certain indications of hurried revision. Marten should be spelt Martin, as in the second edition. Wrong figures are occasionally indicated. The defects, however, are relatively trivial. Viewed as a whole, the issue of the third edition is amply justified by the value of the added matter.

Blood-Pressure: its Clinical Applications. By GEORGE W. NORRIS, A.B., M.D., Assistant Professor of Medicine in the University of Pennsylvania. Third edition. Pp. 448, with 110 engravings and 1 coloured plate. 1917. Philadelphia and New York: Lea & Febiger. $3.50.

NEARLY one half of this volume consists of an account of the physiology of the blood-pressure and of the instruments used in estimating and recording it. These sections are of great value both for their clearness and for purposes of reference. The greater part of the remainder is concerned with the blood-pressure in various medical diseases, only thirty-one pages being devoted to surgical matters. The events which follow hæmorrhage are analyzed in some detail; the work of Crile is described in a fair and critical manner, and other views relating to shock, such as those of Yandell Henderson, are summarized. The treatment and prevention of shock are dealt with by taking one by one the various factors in an operation—e.g., manipulation, anæsthesia, etc.—and discussing the relation of these to the question of blood-pressure. Surgical considerations are confined chiefly to those relating to the abdomen or thorax, and there is no direct reference to limb surgery, and especially to operations upon bones or joints, in the production of shock.

A Text-book of First-Aid and Emergency Treatment. By A. C. BURNHAM, M.D., Medical Corps U.S.R. Pp. 307, with 160 figures and 2 plates. 1917. Philadelphia: Lea & Febiger. $2.00.

THIS book, as its title implies, is intended for the instruction of the unqualified student, and it includes a clearly written account of so much anatomy and physiology as is necessary for the intelligent comprehension of the first principles of diagnosis and treatment. Wounds, wound infection, bandaging, fractures and dislocations, burns and bites, shock and heat stroke, suffocation and drowning, various common regional injuries, poisons, some common diseases (varying from toothache to appendicitis), transportation, and the general principles of nursing, are successively and concisely dealt with, aided by well-chosen ilustrations. It is an up-to-date and most useful book.

SHORT NOTES ON BOOKS.

THE University of London Press has published a most valuable series of Military Medical Manuals under the editorship of Sir Alfred Keogh. Unfortunately these are only translations from the French 'Collection Horizon,' and we deplore the fact that it was not possible for the Metropolitan University to produce original English works on the subjects in question. These books have for the most part been reviewed in the original, and therefore it is not necessary to notice them in great detail. The following are among the most important from a surgical point of view:—

The Treatment of Fractures. Vol. I (Fractures involving the joints), pp. 207, figures 97; Vol. II (Fractures involving the long bones), pp. 305, figures 156. By PROF. LERICHE, edited by

F. F. BURGHARD. These are volumes of great value, especially to English surgeons, because they represent the Lyons school of teaching which has been so little known or understood in this country. Early radical operation, free removal of loose bone, preservation of the periosteum, are the principles maintained throughout. It must be for the thoughtful reader to choose between the dangers and advantages of this teaching, and that of the extreme Liverpool doctrine of the preservation of all fragments.

The Treatment and Repair of Nerve Lesions, pp. 181, figures 62. *Clinical Forms of Nerve Lesions*, pp. 235, figures 78. By MADAME ATHANASSIO-BENISTY, preface by PROF. PIERRE-MARIE, edited by FARQUHAR BUZZARD. These two books will probably remain authoritative when many of the other members of this war series are forgotten. Not only is there a careful description of all types of clinical injury, but there are many original observations relating both to the vascular and vasomotor phenomena complicating the results of the injuries of the peripheral nerves, and to the examination of nerve trunks in regard to the position of the various bundles of fibres of special distribution. Unfortunately it is not possible yet to give very extensive figures relating to the results of surgical intervention; but these volumes are a useful guide to diagnosis, treatment, and prognosis.

Artificial Limbs, pp. 156, figures 210. By PROF. A. BROCA and DR. DUCROQUET, edited by R. C. ELMSLIE. A useful description of general principles and the way in which these have been carried out in France. We could wish that the editor had, in addition to his introduction, added a section to each chapter indicating the types of English and American limbs which had been found most useful in his experience.